D-4012 Diablo Valley College
Physical Education and Kinesiology Complex
Diablo Valley College
Pleasant Hill, CA

December 14, 2018
HMC # 5036004

HMC ARCHITECTS
Architect

WALTER P. MOORE
Structural Engineer

INTEGRAL GROUP
Mechanical/Plumbing Engineers

INTEGRAL GROUP
Electrical Engineer

CHITECTS
ARCHITECTS

No. 4606
REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

No. M 29791
Exp. 06-30-20

No. E15423
Exp. 6-30-2021

CHIANG H.NG
REGISTERED PROFESSIONAL ENGINEER
STATE OF CALIFORNIA

REG
ISTERED
PROFESSIONAL
ENGINEER
STATE OF CALIFORNIA

REG
ISTERED
PROFESSIONAL
ENGINEER
STATE OF CALIFORNIA
D-4012 Diablo Valley College
Physical Education and Kinesiology Complex
Diablo Valley College
Pleasant Hill, CA

December 14, 2018
HMC # 5036004

BKF ENGINEERS
Civil Engineer

JONI L. JANNECKI & ASSOCIATES
Landscape Architect

JENSEN HUGHES
Fire Protection Engineer

AQUATIC DESIGN GROUP
Pool Consultant
TABLE OF CONTENTS

VOLUME 1

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

PROVIDED BY OWNER UNDER SEPARATE COVER

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 35 42 - CALGREEN REQUIREMENTS
SECTION 01 35 43 - SPECIAL ENVIRONMENTAL REQUIREMENTS
SECTION 01 91 13 - GENERAL COMMISSIONING REQUIREMENTS

REMAINDER OF DIVISION 01 SECTIONS ARE TO BE PROVIDED BY OWNER UNDER SEPARATE COVER

DIVISION 02 - EXISTING CONDITIONS

SECTION 02 41 13 - SELECTIVE SITE DEMOLITION
02 41 16 - BUILDING DEMOLITION
02 41 19 - SELECTIVE DEMOLITION

DIVISION 03 - CONCRETE

SECTION 03 10 00 - CONCRETE FORMWORK & ACCESSORIES
03 20 00 - CONCRETE REINFORCEMENT
03 30 00 - CAST-IN-PLACE CONCRETE
03 35 00 - CONCRETE FLOOR FINISHING
03 35 43 - POLISHED CONCRETE
03 81 27 - CORING AND SAWING OF CONCRETE

DIVISION 05 - METALS

SECTION 05 12 00 - STRUCTURAL STEEL
05 31 00 - STEEL DECKING
05 36 20 - ACOUSTIC ROOF DECK - CEILING SYSTEM
05 40 00 - COLD-FORMED METAL FRAMING
05 50 00 - METAL FABRICATIONS
05 52 00 - HANDRAILS AND RAILINGS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

SECTION 06 10 00 - ROUGH CARPENTRY
06 20 00 - FINISH CARPENTRY - INSTALLATION OF DOORS
06 20 00.10 - FINISH CARPENTRY
06 41 16 - CASEWORK
06 61 16 - SOLID POLYMER FABRICATIONS
06 61 19 - QUARTZ SURFACING FABRICATIONS

HMC Architects

TABLE OF CONTENTS
DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION 07 11 13 - BITUMINOUS DAMPPROOFING
07 13 26 - SELF-ADHERED SHEET WATERPROOFING
07 13 54 - PLANT LINERS
07 21 00 - INSULATION
07 21 13 - RIGID THERMAL INSULATION
07 26 13.10 - SELF-ADHERED AIR BARRIERS
07 26 16 - VAPOR BARRIER
07 42 13.10 - METAL WALL PANELS
07 42 36 - SOLID COMPOSITE WALL PANELS
07 46 21 - EQUIPMENT SCREENS
07 54 23 - MEMBRANE ROOFING - THERMOPLASTIC
07 61 00 - SHEET METAL ROOFING
07 62 00 - SHEET METAL FLASHING AND TRIM
07 71 00 - MANUFACTURED ROOF SPECIALTIES
07 72 00 - ROOF ACCESSORIES
07 84 00 - FIRESTOPPING
07 92 00 - JOINT SEALANTS

DIVISION 08 - OPENINGS

SECTION 08 12 13 - HOLLOW METAL FRAMES - WELDED
08 13 13 - HOLLOW METAL DOORS
08 14 16 - FLUSH WOOD DOORS
08 31 13 - ACCESS DOORS
08 32 13 - SLIDING ALUMINUM FRAMED GLASS DOORS
08 33 23 - OVERHEAD COILING DOORS
08 41 13 - ALUMINUM ENTRANCES AND STOREFRONTS
08 44 14 - GLAZED ALUMINUM CURTAIN WALL
08 51 13 - ALUMINUM WINDOWS
08 62 00 - UNIT SKYLIGHTS
08 71 00 - DOOR HARDWARE
08 75 16 - WINDOW OPERATORS
08 80 00 - GLAZING
08 87 33 - DECORATIVE FILMS
08 91 00 - ARCHITECTURAL WALL LOUVERS
08 91 19 - METAL WALL LOUVERS - FIXED

DIVISION 09 - FINISHES

SECTION 09 05 61 - COMMON WORK RESULTS FOR FLOORING PREPARATION
09 06 00 - SCHEDULES FOR FINISHES
09 21 16 - SHAFT WALLS
09 22 16 - NON-STRUCTURAL METAL FRAMING
09 24 00 - PORTLAND CEMENT PLASTERING
09 29 00 - GYPSUM BOARD
09 30 13 - CERAMIC TILE
09 51 00 - ACOUSTICAL CEILINGS - LAY-IN
09 53 23 - ACOUSTICAL SUSPENSION SYSTEMS
09 64 66 - CUSHIONED WOOD FLOORING ASSEMBLY
09 65 13 - RESILIENT BASE
DIVISION 10 - SPECIALTIES

SECTION 10 11 16 - MARKERBOARDS
10 14 00 - SIGNAGE
10 14 33 - EXIT SIGNAGE
10 21 10 - SOLID COLOR REINFORCED COMPOSITE TOILET PARTITIONS
10 22 14 - WIRE MESH PARTITIONS
10 22 26 - OPERABLE PARTITIONS - FOLDING PANELS
10 26 17 - WALL PROTECTION
10 28 00 - TOILET, BATH, AND LAUNDRY ACCESSORIES
10 44 13 - FIRE EXTINGUISHERS AND CABINETS
10 50 00 - HIGH DENSITY MOBILE STORAGE CARTS AND METAL SHELVING
10 51 26 - SOLID PLASTIC LOCKERS
10 71 13 - EXTERIOR SUN CONTROL DEVICES
10 71 14 - EXTERIOR FAÇADE FIN STRUCTURE
10 73 26.10 - WALKWAY COVERINGS
10 80 00 - MISCELLANEOUS SPECIALTIES
10 81 13 - BIRD DETERRENCE SYSTEMS

DIVISION 11 - EQUIPMENT

SECTION 11 23 26 - COMMERCIAL WASHERS AND EXTRACTORS
11 52 13 - PROJECTION SCREENS
11 52 14 - PROJECTOR MOUNTS
11 66 53 - GYM DIVIDER CURTAINS

DIVISION 12 - FURNISHINGS

SECTION 12 24 13 - ROLLER SHADES
12 47 00 - FLAT SCREEN MOUNTS
12 48 00 - ENTRANCE MATS
12 93 00 - SITE FURNISHINGS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13 11 00 - SWIMMING POOL GENERAL REQUIREMENTS
13 11 02 - SWIMMING POOL CONCRETE
13 11 03 - SWIMMING POOL SHOTCRETE
13 11 04 - SWIMMING POOL CERAMIC TILE
13 11 05 - SWIMMING POOL PLASTER
13 11 06 - SWIMMING POOL EQUIPMENT
13 11 07 - SWIMMING POOL MECHANICAL
13 11 08 - SWIMMING POOL ELECTRICAL
VOLUME 2

DIVISION 21 - FIRE SUPPRESSION

SECTION 21 13 00 - FIRE SUPPRESSION SPRINKLER SYSTEMS

DIVISION 22 - PLUMBING

SECTION 22 00 00 - PLUMBING GENERAL REQUIREMENTS
  22 05 13 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
  22 05 14 - VARIABLE FREQUENCY DRIVES FOR EQUIPMENT
  22 05 16 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING
  22 05 17 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
  22 05 19 - METERS AND GAUGES FOR PLUMBING PIPING
  22 05 23 - GENERAL DUTY VALVES FOR PLUMBING PIPING
  22 05 29 - HANGERS AND SUPPORTS FOR PLUMBING PIPING
  22 05 48 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING AND EQUIPMENT
  22 05 53 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
  22 07 16 - PLUMBING EQUIPMENT INSULATION
  22 07 19 - PLUMBING PIPING INSULATION
  22 11 16 - DOMESTIC WATER PIPING
  22 11 17 - RECYCLED WATER PIPING
  22 11 19 - DOMESTIC WATER PIPING SPECIALTIES
  22 11 23 - DOMESTIC WATER PUMPS
  22 13 16 - SANITARY WASTE AND VENT PIPING
  22 13 19 - SANITARY WASTE PIPING SPECIALTIES
  22 13 19.13 - SANITARY DRAINS
  22 14 13 - STORM DRAINAGE PIPING
  22 14 23 - STORM DRAINAGE PIPING SPECIALTIES
  22 33 00 - ELECTRIC DOMESTIC WATER HEATERS
  22 42 00 - PLUMBING FIXTURES

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

SECTION 23 00 00 - HVAC GENERAL REQUIREMENTS
  23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
  23 05 14 - VARIABLE FREQUENCY DRIVES FOR HVAC EQUIPMENT
  23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
  23 05 19 - METERS AND GAUGES FOR HVAC PIPING
  23 05 23 - VALVES FOR HVAC PIPING
  23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
  23 05 48 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
  23 05 53 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
  23 07 13 - HVAC DUCT INSULATION
  23 07 16 - HVAC PIPING AND EQUIPMENT INSULATION
  23 21 13 - HYDRONIC PIPING
  23 21 16 - HYDRONIC PIPING SPECIALTIES
23 25 00 - HVAC WATER TREATMENT
23 31 00 - HVAC METAL DUCTS
23 33 00 - HVAC DUCT ACCESSORIES
23 34 00 - HVAC FANS
23 34 15 - CEILING FANS
23 36 00 - AIR TERMINAL UNITS
23 37 00 - AIR OUTLETS AND INLETS
23 37 23 - HVAC GRAVITY VENTILATOR
23 41 00 - PARTICULATE AIR FILTRATION
23 74 13 - AIR HANDLING UNITS
23 82 19 - FAN COIL UNIT
23 83 00 - RADIANT FLOOR

DIVISION 25 - INTEGRATED AUTOMATION

SECTION 25 00 00 - BUILDING AUTOMATION SYSTEMS

DIVISION 26 - ELECTRICAL

SECTION 26 05 13 - MEDIUM-VOLTAGE CABLES
26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
26 05 43 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS
26 05 44 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLES
26 05 48.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 05 72 - OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY
26 05 73 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY
26 05 74 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY
26 09 13 - ELECTRICAL POWER MONITORING AND CONTROL
26 09 43 - DISTRIBUTED LIGHTING CONTROL SYSTEM
26 22 13 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
26 24 13 - SWITCHBOARDS
26 24 16 - PANELBOARDS
26 27 26 - WIRING DEVICES
26 28 13 - FUSES
26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS
26 43 13 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS
26 51 19 - LED INTERIOR LIGHTING
26 56 19 - LED EXTERIOR LIGHTING

DIVISION 27 - TELECOMMUNICATIONS

SECTION 27 00 00 - COMMUNICATIONS
27 05 26 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS
27 05 28 - PATHWAYS FOR COMMUNICATIONS SYSTEMS
27 05 33 - CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS
27 05 36 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS
27 11 00 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS
27 13 00 - COMMUNICATIONS BACKBONE CABLELING
27 15 00 - COMMUNICATIONS HORIZONTAL CABLELING
DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

SECTION 28 10 00 - ACCESS CONTROL AND ALARM MONITORING SYSTEM
28 20 00 - CLOSED CIRCUIT TELEVISION SYSTEM
28 30 00 - ANALOG ADDRESSABLE FIRE ALARM AND DETECTION SYSTEM
28 31 11 - DIGITAL, ADDRESSABLE FIRE ALARM SYSTEM

DIVISION 31 - EARTHWORK

SECTION 31 11 00 - CLEARING AND GRUBBING
31 12 00 - EXISTING PLANTS TO REMAIN
31 23 00 - EXCAVATION AND FILL
31 23 33 - UTILITY TRENCHING AND BACKFILLING
31 25 00 - EROSION AND SEDIMENTATION CONTROL

DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 05 23 - PORTLAND CEMENT CONCRETE
32 11 32 - AGGREGATE BASE COURSE
32 12 16 - ASPHALT CONCRETE PAVEMENT
32 12 43 - POROUS FLEXIBLE PAVING
32 18 13 - SYNTHETIC GRASS SURFACING
32 31 19 - FENCES AND GATES - ORNAMENTAL METAL
32 31 30 - DECORATIVE ORNAMENTAL PRE-HUNG GATES
32 84 00 - IRRIGATION SYSTEM
32 91 13 - SOIL PREPARATION
32 92 00 - LAWNS AND GRASSES
32 93 00 - PLANTING
32 93 25 - LANDSCAPE MAINTENANCE

DIVISION 33 - UTILITIES

SECTION 33 11 66 - WATER DISTRIBUTION SYSTEM
33 31 00 - SANITARY SEWER SYSTEM
33 41 00 - STORM DRAINAGE SYSTEM

END OF TABLE OF CONTENTS
SECTION 21 13 00

AUTOMATIC SPRINKLER SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY OF WORK

A. The Contractor shall provide all equipment, materials, tools, labor, and accessories, necessary for complete fire protection systems, with said systems being made ready for operation in accordance with the requirements of the specifications, the Diablo Valley College (DVC), Contra Costa County Fire Protection District (CCCFPD), and the Division of the State Architect (DSA). The purpose of the specifications and drawings is to convey to the Contractor the scope of work required, all of which the Contractor is responsible to furnish, install, adjust, and make operable.

B. The omission of any necessary system component as required by the DSA or CCCFPD shall not relieve the Contractor of the responsibility for providing such necessity, without additional cost to the DVC. The Contractor shall visit the site before submitting the bid and shall examine all existing physical conditions that may be material to the performance of the work. No extra payments will be allowed to the Contractor as a result of extra work made necessary by his/her failure to do so. Any case of error, omission, discrepancy or lack of clarity shall be promptly identified to DVC for clarification prior to the bid due date.

C. The Contractor shall provide all devices and equipment required by these specifications and drawings. Under no circumstances will the Contractor delete any equipment or devices without the written directive of the Architect.

D. The drawings are the “approval set” of drawings. The drawings are intended to identify the sprinkler system installation for the purpose of obtaining approval from reviewing agencies. The drawings are further intended to provide a clear representation of the hazard to be protected, the system design concept, the proposed water supply configuration, and building construction information pertinent to system layout.

E. It is the responsibility of the installing Contractor to provide, at no additional cost to the Owner, all required piping, fittings, offsets, and elevation changes to accommodate routing around obstructions and for addressing unforeseen conditions encountered in the field and needed to coordinate with work of other contractors. It is also the Contractor’s responsibility to provide main and auxiliary drains to comply with NFPA 13 whether or not shown on the approval set.

F. In addition to the above, the Contractor shall provide an allowance for installing additional sprinklers and associated piping beyond that noted on the approval set of drawings. The contractor shall incorporate the cost for design, approval, materials and installation for 30 additional sprinklers and associated piping.

G. Changes to the approval set of drawings shall be submitted to the Engineer and DSA for approval. Adding or deleting sprinklers, modifying pipe sizes, and significant changes to pipe routing shall be submitted for approval. Minor deviations in the location of sprinklers...
and pipe routing need not be submitted for approval but shall be recorded and incorporated into the as-built drawings.

H. Changes shall be categorized as required or elective. Required changes include, but are not limited to, the provision of additional sprinklers due to obstructions or architectural changes made during the course of construction. Elective changes include, but are not limited to, modifications to the design shown on the approval set to accommodate substitutions of sprinkler types and locations; type, size, and routing of piping proposed by the Contractor for cost saving and other reasons. The cost of reviewing, processing and obtaining approvals of elective changes by the DVC, Engineer, and DSA shall be paid by the Contractor.

1.02 PERFORMANCE GUIDELINES

A. Work provided under this section shall include, but not be limited to, complete automatic sprinkler systems as outlined in this section, including all labor, materials, design and fabrication drawing preparation needed to provide an operating system, and all of the following:
1. Automatic sprinklers, standpipes and appropriate escutcheons in all spaces in accordance with NFPA 13.
2. Pipe, fittings, and auxiliary drains.
3. Hangers, supports and seismic bracing, including seismic bracing calculations.
4. Ceiling and wall plates.
5. Fire department connection.
7. Coordination with all other trades including the subcontractor providing the detection and alarm system for interfacing with alarm and supervisory functions required by applicable codes and standards.
8. Preparation of all design changes to approved shop drawings, including hydraulic calculations, device manufacturer's literature, and samples. Preparation of as-built and project record drawings.
9. Provision of zone maps depicting the sprinkler zones for each building.
10. Air tests, hydrostatic tests, Contractor's Material and Test Certificates and as-built drawings.
11. Training and operating instructions.
12. Spare parts/sprinklers in cabinet with special wrenches.
13. Painting of all exposed sprinkler piping and supports.
14. All permits and fees for this work.

1.03 SYSTEM ABBREVIATIONS AND DEFINITIONS

A. AHJ - Authority Having Jurisdiction. (Division of the State Architect)
B. Approved - Unless otherwise stated, materials, equipment or submittals approved by the Authority Having Jurisdiction.
D. Architect – HMC Architects.
E. ASME - American Society of Mechanical Engineers.

G. AWS - American Welding Society.


I. Concealed - Where used in connection with installation of piping or conduit and accessories, shall mean, “hidden from sight” as in shafts, furred spaces, in soffits or above ceilings.

J. Contractor - The Company awarded the prime contract for this work and any of its subcontractors, vendors, suppliers, or fabricators.

K. Engineer – JENSEN HUGHES.

L. Exposed - Where used in connection with installation of piping or conduit and accessories, shall mean “visible” or “not concealed.”

M. FM - Factory Mutual.

N. FM Approved - Materials or equipment approved by Factory Mutual and included in the most recent edition of the FM Approval Guide.

O. Furnish - Supply materials.

P. gpm - Gallons per minute.

Q. Install - Install materials, mount, and connect equipment or assemblies.


S. Owner - Diablo Valley College.

T. Provide - Furnish, install, connect, and make operational.

U. psi - Pounds per square inch.

V. QR - Quick-response sprinkler.

W. Remove - Remove material and equipment and restore surface.

X. UL - Underwriters Laboratories, Inc.

Y. UL Listed - Materials or equipment listed by Underwriters Laboratories and included in the UL Fire Protection Equipment Directory.

1.04 RELATED WORK IN THIS CONTRACT

A. Section 283100 - Fire Alarm System.
1.05 DESIGN CRITERIA

A. Automatic fire sprinkler systems shall utilize quick-response sprinklers unless otherwise specified. Wet-pipe systems shall be installed in all areas. The minimum acceptable design shall be in accordance with NFPA 13 and the following:

1. Classrooms, lounges, corridors, offices, locker rooms, examination rooms, training rooms, ice room, toilets, and similar spaces shall be classified as Light Hazard occupancy and shall be designed using a density of 0.10 gpm per square foot over a minimum 1,500-square-foot design area. System design shall include an allowance of 100 gallons per minute for inside/outside hose streams.

2. The laundry facility, storage rooms, electrical rooms, mechanical rooms, janitor closets, and similar spaces shall be classified as Ordinary Hazard Group 1 occupancy and shall be designed using a density of 0.15 gpm per square foot over a minimum 1,500-square-foot design area. System design shall include an allowance of 250 gallons per minute for inside/outside hose streams.

3. Sprinklers in finished areas shall be quick-response recessed pendent sprinklers with a white finish and white escutcheon. Sprinklers in unfinished areas and areas with no ceiling shall be quick-response upright sprinklers with brass finish.

4. One individual floor control valve assembly consisting of a supervised butterfly control valve, check valve, test and drain connection, waterflow switch, and pressure gauge will be provided for each of the buildings in the PE/K Complex. Building A will be provided with two assemblies; one for Building A East and one for Building A West.

5. System main and inspector’s test drains shall be connected to sanitary sewer.

B. Any hydraulic calculations required for changes shall be performed in accordance with NFPA 13. A minimum 10-psi cushion or safety factor/margin between the available pressure and the calculated required pressure shall be incorporated into all hydraulic calculations.

1.06 APPLICABLE CODES, STANDARDS AND PUBLICATIONS

A. The design and installation shall be in conformance with all applicable local, state, and national codes and standards.

B. Reference Codes: The following codes are included as part of this section:


C. Reference Standards and Publications: The following standards and publications are included as part of this section:

1. National Fire Protection Association (NFPA):

2. Factory Mutual Systems (FM) Publication:
   a. Approval Guide.

3. Underwriters Laboratories, Inc. (UL) Publication:
1.07 REGULATORY AGENCIES

A. All material, design, installation and other work shall conform to all applicable regulatory agencies, including the following:
   1. Federal, state, and local building codes and ordinances, and agencies.
   2. CCCFPD requirements.

B. Contractor shall include all costs associated with complying with the applicable regulatory agencies. Failure to specifically reference on these plans and/or specifications any restrictions, materials, and/or work required by the regulatory agencies shall not relieve the Contractor of the responsibility for fully complying with the regulatory agencies without additional cost to the Owner.

1.08 APPROVALS

A. Obtain acceptance of fabrication drawings and materials from the Engineer prior to submittal to DSA.

B. Obtain approval of fabrication drawings from DSA prior to fabrication and installation of materials.

1.09 SUBMITTALS

A. Fabrication Drawings (developed by Contractor)
   1. The approved plans comply with NFPA 13 as working drawings. If the Contractor requires fabrication drawings in order to complete the installation, the fabrication drawings shall be developed by the Contractor.
   2. Submit four copies of fabrication drawings for review and acceptance by the Engineer and DSA (if appropriate).
   3. Contractor shall submit complete system packages. Partial system submittals will be rejected.
   4. Prepare fabrication drawings at minimum scale of 1/8-inch equals 1 foot for plans, and 1/4-inch equals 1 foot for details. Show all piping, sprinklers, hangers, type of pipe, tube connections, outlets, roof construction, and occupancy of each area, including ceiling and roof heights as required by NFPA 13.
   5. Fabrication drawings shall include details of earthquake sway bracing with any required calculations.

B. Changes
   1. Make no changes in installation from layout as shown on the approved drawings unless change is specifically approved by Engineer. This does not include minor revisions for the purpose of coordination.
   2. Any pipe fabricated and/or installed before all approvals are obtained at the Contractor's own expense and responsibility. Any changes made to the approved drawings other than as stated above are at the Contractor's own expense and responsibility.
   3. Contractor shall provide hydraulic calculations for all modified sprinkler layouts. Hydraulic calculations shall include a water supply graph and hydraulic cover sheet. The cover sheet shall include the name and location of the calculated area, ceiling height, occupancy, design criteria, sprinkler spacing, system type, sprinkler make, model, size, k-factor and temperature rating, flow requirements, C factor
used, water supply data and source of information, and commodity storage class, height, and configuration.

4. Where flexible sprinkler drops are used, the friction loss and modified k-factor for the sprinkler and flexible sprinkler drop shall be provided.

5. Contractor shall provide data from manufacturer for all changes and substitutions on the following devices, including installation, maintenance, and testing procedures, dimensions, wiring diagrams, etc. Where any devices that are provided or furnished involve work by another trade, submit additional data copies directly to that subcontractor. Where manufacturer's data sheets show multiple equipment or model numbers, indicate with arrow the equipment to be provided.
   a. Sprinklers and escutcheons.
   b. Pipe, fittings, and hangers.
   c. All other system components.

C. As-Built and Project Record Drawings
1. Maintain at the site an up-to-date marked set of approved drawings, which shall be corrected daily and delivered to Owner upon completion of work.
2. Contractor shall utilize the marked-up drawings to produce a set of Project Record Drawings. Upon completion, furnish Owner with four sets of blackline prints and one set in electronic AutoCAD “DWG” and Portable Document Format (PDF) format of each reviewed shop drawing, revised to show “as-built” conditions.

D. Final Inspection and Test
1. Upon completion of final inspections and tests, as required by appropriate NFPA Standards and these specifications, submit documentation of all test results and copies of the Standard Contractor’s Material and Test Certificates to Owner.

1.10 SPARE PARTS

A. Provide spare sprinkler cabinets, complete with sprinklers of assorted temperature ratings of the type necessary and in use throughout the installation as required by NFPA 13. Each cabinet shall be equipped with one special sprinkler wrench required for each type of sprinkler installed.

B. Provide list of sprinklers installed in each building in each sprinkler cabinet per NFPA 13, Section 6.2.9.7

C. Install new sprinkler cabinets at the sprinkler riser locations. Confer with Owner for exact locations of cabinets.

1.11 WARRANTY

A. The Contractor shall warranty all materials and workmanship for a period of one year beginning with the date of final acceptance by Owner in accordance with the General Conditions.

1.12 QUALITY ASSURANCE

A. The Contractor shall be fully experienced and licensed (California C-16) in all aspects of the fire protection systems herein specified.
B. The Contractor shall provide a single person as a point of contact who is responsible for issues of scheduling, coordination, and quality control.

1.13 EMERGENCY SERVICE

A. The Contractor shall provide emergency repair service for the sprinkler/standpipe system within four hours of a request for such service by Owner during the guarantee period. This service shall be available on a 24-hour per day, seven-day per week basis.

1.14 TRAINING AND OPERATION INSTRUCTIONS

A. The Contractor shall conduct two training sessions of 4 hours each to familiarize the facility personnel with the features, operation, and maintenance of the fire protection systems. Training sessions shall be scheduled with Owner by the Contractor at a mutually agreeable time to the Contractor and Owner.

B. Operating Instructions

1. At the completion of the work, provide a site plan indicating the locations of all control valves, low point drains, and inspector's test valves. The plan shall be neatly drawn and color-coded to indicate the portion of the building protected by each system. Submit four sets of plans to Owner.

2. Furnish three copies of printed operating and maintenance instructions to Owner, and adequately instruct Owner's maintenance personnel in proper operation and test procedures of all fire protection components provided, furnished, or installed.

1.15 PERMITS AND FEES

A. Pay for all permits, fees and charges required for this work.

PART 2 - MATERIALS

2.01 GENERAL

A. All components shall be UL listed or FM approved for the intended purpose. Components shall be used in accordance with the manufacturer's recommendations and its UL listing and/or FM approval.

B. The naming of manufacturers in the specifications shall not be construed as eliminating the materials, products or services of other manufacturers and suppliers providing approved equivalent items.

C. The substitutions of materials or products other than those named in the specifications are subject to proper approval of Owner granted in writing.

2.02 PIPE

A. Pipe shall be new, designed for 175 psi, non-shock, cold water working pressure, conforming to ASTM specifications, and have the manufacturer's name and brand along with the applicable ASTM standard marked on each length of pipe.

1. Steel: Steel piping shall be black. Overhead pipe used shall be black steel and must comply with the standards noted in NFPA 13. Dimensions for all overhead
pipe must be in accordance with the American Standard for Wrought Steel and Wrought Iron Pipe ANSI B36.10-1975 for pressure up to 300 psi. Piping shall be Schedule 40 pipe. Schedule 10 pipe maybe be used for sizes larger than 2 inches. Light wall piping having a wall thickness less than Schedule 10 shall not be used. Schedule 40 pipe ends shall be welded, threaded or cut grooved. Schedule 10 pipe ends shall be roll grooved. Pipe and preparation shall conform to the fitting manufacturer’s recommendations.

B. Where piping is subjected to pressures exceeding 175 psi, pipe and fittings rated for the pressures developed shall be used.

2.03 FITTINGS

A. Piping connections for steel pipe shall be threaded, flanged or grooved, and rated for 175-psi working pressure. Plain end fittings and couplings are not permitted. All fittings shall be suitable for use in sprinkler and standpipe systems as defined in NFPA 13 and 14.

1. Threaded fittings shall be cast iron, 125-pound class, black, and in accordance with ANSI B 16.4 or malleable iron, 150-pound class, black and in accordance with ANSI B 16.3. Bushings shall not be used. Welded fittings shall be steel, standard weights, black, and in accordance with ASME B 16.9, ASME B 16.25, ASME B 16.5, ASME B 16.11 and ASTM A 234.

2. Grooved fittings shall be malleable or ductile iron joined with rigid or flexible couplings with approved gaskets. Groove-type fittings shall be UL listed or FM approved for fire protection. Fittings shall be manufactured by Victaulic, Gustin-Bacon, or equal.

a. Grooved couplings and reducers shall be malleable or ductile iron conforming to ASTM A47. Grooved couplings to be malleable or ductile iron having clamps to engage and lock, designed to permit some angular deflection, contraction, and expansion; composition sealing gaskets recommended by the manufacturer, steel bolts, nuts, and washers. Coupling gasket shall be molded Elastomer (EPDM) Victaulic grade “E” (TYPE A), Gustin-Bacon Type W or as otherwise recommended by the manufacturer for dry pipe systems, or equal.

b. Grooved couplings and reducers shall be of the same manufacturer as used for the grooved fittings. Grooved couplings may be of flexible or rigid type. Flanged fittings shall be Class 150 steel, rated at 200-psi working pressure and provided match adjacent equipment or fittings. Where using bolt connections, the length of the bolts shall not protrude as to prevent the use of a socket wrench on associated nuts.

c. Flanged bolts shall be hexagon head machine bolts with heavy semi-finished hexagon head nuts, cadmium plated, having dimensions in accordance with ANSI B 18.2. Gaskets shall be full-faced of 1/16-inch minimum thickness red sheet rubber.

2.04 FLEXIBLE SPRINKLER CONNECTION

A. Standard flexible sprinkler connections shall be used where suspended ceilings with T-bar and stud framing, and floating ceilings with T-bar, are provided. Where used, the entire listed assembly shall be provided. Connection shall be to a standard screwed fitting on the branch line, press fittings shall not be used. Flexhead or approved equal.
2.05 SPRINKLERS

A. Sprinkler shall be standard orifice (1/2-inch), quick-response type and have an ordinary temperature classification. Temperature ratings shall be 155-degrees Fahrenheit in all areas except where higher temperature ratings are required by NFPA 13. Sprinklers shall be manufactured by Tyco, Viking, or approved equal.

B. Pendent sprinklers located in finished ceilings shall be recessed pendent type with white finish and white metallic escutcheon. Sprinklers located in areas without finished ceiling shall be brass upright or pendent.

C. Sprinklers exposed to the exterior shall be corrosion resistant with corrosion-resistant escutcheon.

D. Sidewall and extended-coverage sprinklers shall be quick-response type and listed for the hazard classification being protected. The installation of sidewall and extended-coverage sprinklers shall comply with NFPA 13 and manufacturer’s instructions.

E. Where surface mounted lights are provided, sprinklers shall be provided with a 2-piece escutcheon to clear ceiling mounted obstructions.

2.06 VALVES

A. Control valves shall be UL listed/FM approved indicating type. All valves controlling building automatic sprinkler systems shall be butterfly or outside screw and yoke (OS&Y) valves. Valves shall be Powhatan, Croker, Elkhart, Grinnell, Stockham, Viking, Potter-Roemer, Victaulic, or approved equal.
   1. OS&Y valves shall be iron body, bronze trim, rising stem with solid wedge and resilient seat.
   2. Butterfly valves shall be gear operated, indicating type with integral valve supervisory switch, manufactured by Victaulic or equal.

B. Drain, trim, and test valves shall be approved.
   1. Main drain, auxiliary drain and inspectors test valves shall be globe valves, bronze body, rising stem, inside screw, renewable composition disc manufactured by Nibco, Stockham, or equal. Globe valves up to 1 inch to be Nibco KT-65, Stockham or equal. Globe valves 1-1/4 inches to 30 inches to be Nibco KT-211-W, Stockham, or equal.
   2. Drains shall discharge to sanitary sewer.
   3. Combination test/drain valves may be used.

C. Check Valves
   1. Check valves for water supply, fire department connections, and risers shall have removable covers for maintenance without removing the valve from the system.
   2. Check valves in the trim shall be approved.

2.07 PRESSURE GAUGES

A. Listed/approved with range approximately twice-maximum pressure at point of connection, 3-1/2-inch diameter, complete with 1/4-inch threaded inlet with shut off valve with 1/4-inch plugged outlet.
2.08 HANGERS AND SUPPORTS

A. Swivel rings and building attachments shall be listed/approved.
   1. Trapeze/hanger component station module shall meet or exceed values listed in NFPA 13.
   2. Earthquake sway bracing compartments shall meet or exceed sizes listed in NFPA 13.
   3. The hanger components used in the Training Room in Building A shall be listed/approved for use with the Toris A roof deck ceiling system being installed in that location.

2.09 SLEEVES FOR WALL/FLOOR PENETRATIONS

Sleeves through walls and floors, where provided, shall be of a type that can be made watertight and fire stopped. Sleeve sizes shall be as required by NFPA 13 and 14 for Earthquake Protection.

2.10 SIGNS

A. Valve signs shall indicate purpose and system of each control, test, trim, and drain valve. Hydraulic information sign shall meet requirements of NFPA 13. New hydraulic information signs shall be provided for every riser that serves a sprinkler zone being modified.

B. Contractor shall provide general information signs per NFPA 13, Section 25.6.

2.11 WATERFLOW ALARM AND SUPERVISORY DEVICES

A. Devices shall be listed/approved for the intended application and compatible with the alarm system.
   1. Valve supervisory switches shall be provided on all control valves. Switch shall not interfere with the normal operation of the valve. Supervisory switches shall be provided as part of the sprinkler work and wired as part of the fire alarm work.
   2. Supervisory (tamper) switches provided with butterfly/ball valves by the valve manufacturer shall be listed/approved as an assembly.

B. Waterflow Switches
   1. Waterflow alarm indicators shall be vane-type except for dry systems. Switches shall be instantaneously recycling with pneumatic retard. Switches shall be provided as part of the sprinkler work and wired as part of the fire alarm work.
   2. Switches shall be provided with two sets of normally open contacts. Waterflow alarm switch shall be installed before the system has been hydrostatically tested. Waterflow switch shall be UL listed or FM approved. Switches shall be manufactured by Potter or equal.

2.12 FIRE DEPARTMENT CONNECTION

A. Fire Department Connection to be brass, exterior fire department connection with brass escutcheon plate, and a minimum of two 2-1/2-inch connections threaded to match those on the local fire protection service, with polished brass caps and chains. Provide
escutcheon with integral raised letters "Automatic Sprinkler". Install an automatic ball drip between fire department connection and check valve.

B. Locate fire department connection near backflow preventer.

2.13 AIR VENTS

A. Air vents shall be installed at the high point(s) on the fire sprinkler system piping to remove as much air as possible from the system during or after filling. Air vents shall be UL listed and/or FM approved. Air vents shall be manufactured by Potter, Engineered Corrosion Solutions, or equal.

2.14 OUTSIDE BELL

A. Provide 10-inch outside bell. Provide unswitched 120 VAC power wired through waterflow switch normally open dry contact. Locate bell on exterior wall at riser location. Outside bell(s) shall be UL listed and/or FM approved. Approved identification signs shall be provided. Outside bell(s) shall be manufactured by Potter or equal.

PART 3 - EXECUTION

3.01 GENERAL

A. Product Delivery
   1. Delivery of Materials: Delivery of all materials and equipment to the job site shall be scheduled to assure compliance with the predetermined construction schedules.
   2. Storage of Materials, Equipment, and Fixtures: Contractor shall be responsible for storage of materials on job site, including furnishing of any storage facilities or structures required.
   3. Handling Materials and Equipment: Contractor shall be responsible for on-site handling of materials and equipment.

B. Clean-up
   1. Maintain the premises free from accumulation of waste materials or rubbish caused by this work.
   2. At the completion of the work, removed all surplus materials, tools, etc., and leave the premises clean.

C. Leak Protection
   1. Damage: Protect all unfinished work to prevent damage and furnish protection of all surrounding areas where necessary.
   2. Leak Damage: The Contractor shall be responsible during the installation and testing periods of the fire protection system for any damage to work in progress, to the building or its contents caused by leaks in any equipment, by unplugged or disconnected pipes or fittings, or by overflow, and shall pay for the necessary replacements or repairs to work in progress or building damaged by such leakage.
3.02 FABRICATION

B. Pipe Ends
   1. Ream and remove burrs after cutting pipe. Standard wall pipe ends shall be welded, threaded, cut grooved, or plain end.
   2. Thin wall pipe ends shall be plain end, welded or roll grooved in accordance with the fitting manufacturers' recommendation.
   3. Threads shall be in accordance with ASME B1.20.1 “Pipe Threads, General Purpose (inch).” Each thread on light wall pipe shall be gauged before fitting make-on.

C. Grooved Ends
   1. Pipe minimum thickness, squareness, and out-of-roundness shall be in accordance with the coupling manufacturers specifications.
   2. Pipe surface shall be free of indentations, projections, or roll marks from the end of the pipe to the groove.
   3. Pipe of less than minimum wall thickness listed shall not be cut grooved.

D. Welding
   1. No field welding of sprinkler/standpipe piping shall be permitted.
   2. Piping may be shop welded using acceptable welding fittings. Welding methods shall comply with all the requirements of AWS B2.1, “Specifications for Qualification of Welding Procedures and Welder for Piping and Tubing.”
   3. Certified records shall be maintained upon the completion of each weld, welder shall stamp an imprint of their identification into the side of the pipe adjacent to the weld.
   4. Welds shall be inspected at the site by the fire department prior to installation. Piping with welded fittings installed without such prior inspection shall be rejected.

3.03 INSTALLATION

A. General
   1. A clean set of prints or shop drawings shall be maintained at the site and marked up to show any changes.
   2. Piping shall be installed above ceilings except as noted otherwise. Install piping in exposed areas as high as possible using necessary fittings and auxiliary drains to maintain maximum clear headroom.
   3. Complete installation and place in service during nonworking hours in all areas where materials are stored or in place.
   4. Coordinate to provide an operating system before Owner’s scheduled moving of combustible contents into building, except as specifically permitted by CCCFPD.
   5. Install paired flanges and numbered test blanks to provide partial protection during construction. Maintain a “test blank log” at the site during construction to assure removal of all blanks at completion of job.
   6. Schedule 40 steel pipe shall be used for drop nipples to pendent sprinklers.
   7. Flushing connections shall be installed at ends of cross-mains.

B. Joining Pipe
   1. Steel Pipe
      a. Apply tape or joint compound to male threads only.
      b. Threaded close nipples shall not be used.
c. Grooved and plain end joints shall be made in accordance with the fitting manufacturer recommendations.

C. Drain and Test Piping
1. Where drain and test piping is piped through wall to atmosphere, install a 4-foot or greater length of pipe from valve outlet to wall penetration.

3.04 SPRINKLERS

A. General
1. Pendent sprinklers shall have symmetry, which is in alignment and parallel to ceiling fixtures, walls, and building features.
2. Pendent sprinklers shall be located at center of tile.
3. Adjustable escutcheons shall not be used.
4. Install sprinklers as required by NFPA 13 with regard to ducts, obstructions, and partitions.
5. Sprigs shall be provided wherever necessary to provide proper deflector distances in accordance with NFPA 13 requirements.

B. Sprinkler Guards
1. Provide guards on sprinklers within 7 feet of finished floor or wherever sprinklers may be subject to mechanical damage.

3.05 VALVES

A. General
1. Valves shall be installed with sufficient clearance for operation, testing, and maintenance.
2. Where wafer bodied valves are used, they shall be installed so that the discs do not interfere with other components.

B. Control valves shall be installed so that valve position indicator is visible.

C. Drain, Test, and Trim Valves
1. Valves shall be installed no more than 7 feet, 0 inches above the finished floor and be accessible.

D. Check Valves
1. Install check valves horizontally or vertically (flow upward).

E. Automatic Drip (ball drip) Valve
1. Install horizontally, pipe discharge to outside or suitable drain.

3.06 PENETRATIONS

A. Piping passing through any wall, floor or rated assembly shall be provided with clearance around the entire circumference of the pipe as required by NFPA 13. Piping 3-1/2 inches and smaller shall have a minimum 1-inch clearance around the entire circumference of the pipe and piping 4 inches and larger shall have a minimum 2-inch clearance around the entire circumference of the pipe. The exception is clearance for piping penetrating the insulated ceiling panels shall be as small as possible. Careful coordination with the
other trades is required. Where fire alarm conduit or conductors penetrate the same wall as sprinkler piping, size core for both with proper clearance.

B. Where cutting or drilling of floors, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of pipe, conduit, or other work, this work shall be carefully done and affected surfaces and structures shall be fully restored to original condition. Any damage to building, piping, or equipment caused by the Contractor shall be repaired at no additional cost to Owner. All such work shall be performed by skilled workers in their respective trades, at the expense of the Contractor.

C. In accordance with section 07841, Through-Penetration Firestop Systems, the annular space between the floor, wall, or ceiling, and the sprinkler pipe is fire-rated assemblies shall be filled with a waterproof, UL listed, fire stopping material with a fire-resistance rating equivalent to, or greater than, that of the floor or the wall being penetrated. The finish of the fire stopping material shall be neat, smooth, and flush with member being penetrated in finished areas.

D. Sprinklers penetrating ceilings having an area of greater than 2,500 square feet shall be provided with a 1-inch annular space around sprinklers and piping penetrating the ceiling. Oversized escutcheons or ceiling plates shall be used where this occurs. The annular space is not required where flexible sprinkler drops are installed or where the Structural Engineer has determined they are not required based on seismic evaluation of the ceiling.

3.07 PRESSURE GAUGES

A. Gauges shall be installed vertically, with three-way valve with 1/4-inch plugged outlet, and as follows:
   1. Above and below wet system riser check valves.
   2. At each water supply and inlet of floor control valve.
   3. At inlet and outlet of each pressure reducing floor control valve.

3.08 HANGERS, SUPPORTS, AND EARTHQUAKE BRACING

A. General
   1. All piping must be substantially supported from building structure and only approved types of hangers shall be used. Piping lines under ducts shall not be supported from ductwork, but shall be supported from building structure with trapeze hangers where necessary or from steel angles supporting ductwork in accordance with NFPA 13.
   2. All thread rods shall not be bent. Hanger components shall be ferrous.
   3. Where attached to bar joists, attach hanger to top chord of bar joists only.

B. Feed and Cross-Mains
   1. Install at least one hanger per length of pipe up to 8 feet in length joined by grooved couplings.
   2. Use rigid grooved couplings where more than two couplings are used per run.

C. Risers
   1. In one story buildings, install riser clamp or hanger on horizontal connection close to riser.
2. Where ceiling heights exceed 25 feet, install at least one lateral support per each riser pipe section.
3. In multi-story buildings riser/standpipe shall be supported at lowest level and alternate levels above using riser clamp.
4. Install rigid coupling in standpipe except in seismic areas.

D. Earthquake Protection
1. Install bracing meeting the requirements of the California Building Code and NFPA 13.
2. Install flexible joints and sub-bracing as provided in NFPA 13.

3.09 SLEEVINGS, WALL, AND FLOOR PENETRATIONS
A. Sleeves through fire rated assemblies shall be fire stopped.
B. Sleeves through floors shall be made watertight.
C. Install metal wall and ceiling plates and exposed pipe in finished brass.

3.10 SIGNS
A. Valves
   1. Secure to each valve with corrosion resistant wire or chain.
B. Hydraulic Design Information
   1. Secure directly to the riser with adhesives or to riser with corrosion resistant fasteners.

3.11 WATERFLOW ALARMS AND SUPERVISORY DEVICES
A. Alarm and Supervisory Switches
   1. Deliver wiring diagrams to alarm contractor.
   2. Install alarm water flow and air supervisory switches in accordance with switch and valve manufacturer’s instructions.
   3. Install and adjust valve supervisory switches in accordance with switch manufacturer’s instructions.

3.12 SYSTEM ACCEPTANCE
A. Tests
   1. General system inspections and tests shall be coordinated with the AHJ. Problems noted during testing such as air or water leaks, difficulty in operating valves, and alarm failures shall be corrected before the Contractor leaves the job.
   2. Hydrostatically test all piping at 200 psi for 2 hours. If the highest static pressure at the lowest point in the system exceeds 150 psi, the system shall be tested at 50 psi more than the highest static pressure.
   3. Main drain shall be opened wide until pressure stabilizes then slowly closed, noting and recording flowing (residual) and static (non-flow) pressure.
B. Valve Operation
   1. Operate each valve through its entire range. Adjust valve-packing glands if applicable.

C. Waterflow and Supervisory Devices
   1. Coordinate testing of electric components with the alarm contractor.
   2. Each waterflow device shall be tested in accordance with NFPA 72 by opening the inspector’s test or alarm test valve.
   3. Each valve supervisory device shall be tested by operating the valve wheel/crank.
   4. Verify all signals have been noted by the fire alarm control panel and each audible alarm device operates.

D. Contractor’s material and test certificates shall be completed for each system/sub-system/floor and signed by the installer and AHJ or other witness.

E. Training
   1. General – In addition to the tests required above and witnessed by Owner, conduct one, 2-hour training sessions to familiarize the representatives with all operating features of the system, including control valve, drain and test valve locations and operations.
   2. Provide Owner with:
      a. A small-scale plan of the system/building showing locations of control, drain, and test valves.
      b. Component manufacturers’ inspection and testing manuals.

END OF SECTION
SECTION 22 00 00
PLUMBING GENERAL REQUIREMENTS

1.01 RELATED DOCUMENTS
A. Division 01.
B. The requirements of the General Conditions and Supplementary Conditions.

1.02 SUMMARY
A. Furnish and install a complete (fully tested, adjusted, and ready for operation) plumbing system as described by the Contract Drawings and Specifications.
B. The design described in the Project documents reflect a building designed for low consumption of energy and water and minimum environmental footprint. Any modifications to the systems described herein shall maintain or improve on the sustainability and energy efficiency features of the project.
C. All design modifications that pertain to system selection, system energy efficiency, water and energy use, material selection and indoor air quality issues shall require the approval of Integral Group.
D. Include incidental details not usually shown or specified, but necessary for proper installation and operation.
E. Check, verify, and coordinate Work with Contract Drawings and Specifications prepared by all other trades. Include modifications, relocations, and adjustments necessary to complete work or avoid interference with other trades.
F. Where architectural features govern location of Work, refer to Architectural Drawings.
G. Contractor may install additional piping, fittings, and valves, not shown on the drawings, for testing purposes or convenience of installation. Where such materials are installed, they shall comply with the specifications and shall be properly sized for the system and operation. Remove such installed materials when they interfere with design conditions or as directed by the Architect.
H. LEED: This building shall be LEED certified. Contractor and their subs shall provide all relevant support documentation pertaining to the LEED credits that relate to their work.

1.03 CODES AND STANDARDS
A. All work and materials shall be in full accordance with the latest local rules and regulations, applicable sections of the California Code of Regulations, Title 24, State Fire Marshal, the Safety Orders of the Division of Industrial Safety, the California Electric Code and applicable State requirements. Nothing in these Plans and Specifications is to be construed to permit work not conforming to these requirements.
B. Codes and Standards: As a minimum, the design of the PLUMBING system shall meet the following codes and standards (Latest Adopted Edition):

1. 2016 California Building Code (CBC)
2. 2016 California Plumbing Code (CPC)
3. 2016 California Mechanical Code (CMC)
4. 2016 California Electrical Code (CEC)
5. 2016 California Energy Efficiency Code (CEEC or Title 24)
6. 2016 California Fire Code (CFC)
7. 2016 California Green Building Standards Code (CGBSC or CALGreen)
8. ADA Standards for Accessible Design- Code of Regulations (Including Amendments)

C. Wherever the Specifications call for or describe materials or construction of better quality or larger sizes than are required by the above rules and regulations, these Specifications shall govern. Should there be any direct conflict between the above rules and regulations and the Specifications the rules shall govern.

D. Equipment shall have UL label listing.

1.04 DRAWINGS

A. Layout of the equipment and work is diagrammatic, unless specifically dimensioned. Drawings and details shall be checked for interferences before installing the work. Any interference noted between different drawings, and between drawings and actual field conditions shall be brought to the attention of the Architect and Engineer of Record for a decision. The right is reserved to make any reasonable change in location of equipment without additional expense to the Owner.

B. For purposes of clarity and legibility, drawings are diagrammatic to the extent that many offsets, bends, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Exact routing of piping and locations of equipment shall be governed by structural conditions and obstructions. Contractor shall make use of all data in Contract Drawings and Specifications and field conditions.

C. In the event a major re-routing of a system appears necessary, Contractor shall prepare and submit for approval, shop drawings of the proposed rearrangement. Because of the diagrammatic nature and small scale of the Contract Drawings, all necessary offsets, adjustments, and transitions required for the complete installation are not shown. Contractor shall carefully investigate the structural and finish conditions affecting all the Work and shall arrange such Work accordingly, furnishing such fittings, equipment, accessories, etc., as may be required to meet such conditions, at no increase in Contract Sum.

D. All dimensions and locations of equipment, doors, partitions, etc., are to be taken from the architectural plans but shall be verified at the site.

1.05 SUBMITTALS

A. See Division 01 “Administrative Requirements”, for submittal procedures.
B. Plumbing and related submittals are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Engineer of Record will review submittals and provide comments within the following timeframe after receipt by the Engineer:
   1. For typical submittals, allow 10 working days.
   2. For large or complex submittals, allow 15 working days. Determination of “large and complex” submittal shall be at the discretion of the Engineer of Record.
   3. Do not send Engineer of Record more than 10 submittals in a contiguous period of 5 working days. If excess submittals are received, review period will be extended as necessary to perform proper review. Submittals will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.
   4. These submittal review periods supersede and take precedence over periods defined in Division 01, unless Division 01 allows for longer review periods.
   5. Submittal review periods shall not be reduced from the times herein except by agreement with the reviewing entity, in advance and in writing.

D. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Use the same identifiers (e.g. equipment tags) used in Contract Drawings.

E. Submittals shall be provided in digital format.
   1. Provide a separate file for each submittal. For submittal packages, provide a separate file for each subsection (e.g. hardware cut sheets and shop drawings for the same Section shall be provided as separate files).
   2. Product cut sheets, test forms and other text documents shall be provided in word searchable digital format. Acceptable formats are MS Word, PDF (generated from another electronic document and word-searchable; scans of paper documents are not acceptable), and HTML; other formats require approval prior to submission.
   3. Drawings and schematics shall be provided in PDF format and in AutoCAD compatible format.
   4. Scanned paper documents are not acceptable
      a. Exception: original signed documents, such as qualifications, inspection certificates, and warranty documents.
   5. Hardcopy (paper) submittals are not acceptable and shall not be provided except as noted in Article 1.02).
   6. Submittals provided in the wrong format will be returned without action.

F. Submission and Resubmission Procedure
   1. Optional Pre-Submittals: At Contractor’s option, material may be submitted unofficially via email directly to the Engineer of Record for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time, and to provide a venue to discuss technologies, products, designs or implementation strategies that are novel or unique.
2. Each submittal shall have a unique serial number that includes the associated Specification Section followed by a number for each sub-part of the submittal for that Specification Section, such as SUBMITTAL 220000-01. There is no requirement to assign particular serial numbers to any specific submittals – serial number assignment is arbitrary. The only requirements are that the serial numbers be sequential (to avoid confusing gaps) and, most importantly, consistent across all submittal correspondence.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 220000-01 REVISION 1.

4. Submit one copy of submittal in electronic format specified in Paragraph 1.05E. Submissions made in the wrong format will be returned without action.

5. Include with each submittal and resubmittal a copy of the relevant specification section(s) noting on each paragraph and sub-paragraph(s) the following:
   a. CONFORMS: Contractor has verified that the submitted product conforms to the noted requirement(s).
   b. CONFORMS AS NOTED: Contractor has verified that the submitted product conforms to the noted requirement(s) by means of being equal to or higher quality and / or performance.
   c. NON-CONFORM: Contractor has verified that the submitted product does not conform to the noted requirement(s) and delineates each deviation from the specification requirements.
   d. NOT APPLICABLE: Contractor has verified that the noted requirement(s), in their opinion do not apply to this product, delineating the reasons for this decision.
   e. Include with each submittal and resubmittal a copy of the relevant specification section(s) the printed name of the contractor reviewer, their signature, the company name, and date of review.

6. Revise submittal
   a. Respond to all comments:
      1) Revise initial submittal to resolve review comments and corrections.
      2) Provide complete responses to comments or suggestions which are not practical to implement in the opinion of the Contractor.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.
   d. Resubmittals that are not responsive to all comments will be returned without action.

7. Resubmit revised submittals until no exceptions are taken.

8. Once submittals are accepted with “No Exceptions Taken” or “Approved As Noted”, provide:
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

G. Submit shop drawings, a list of proposed material and equipment manufacturers and the names of Subcontractors.

H. Shop drawings shall be provided for all plumbing systems for all floors of the building. Plumbing shop drawings shall also be provided for the under-slab systems (under the foundation slab) and slab-embedded systems such as floor drains.
I. Materials and methods with which the words "for approval" or "approved" are used, and materials and methods which differ from those specified, shall be submitted.

J. Prepare and submit shop drawings, sections, details and diagrams to minimum scale 1/4" = 1'-0". Drawings shall be coordinated, dimensioned and indicate equipment, pipe, duct, fire protection, and electrical in relation to architectural and structural features. Include minor piping, drains, air vents, etc. Indicate exact locations and elevations of valves, piping specialties, access doors, dampers, etc. Electronic submittal is encouraged.

K. Submit manufacturer’s specifications, product source, data sheets, certified equipment drawings and installation instructions, including installation dimensions, clearances, weights, materials, finishes, color selection, accessories, acoustical characteristics, capacity and full load and part load performance curves; complete with electrical data, motor horse power, KW; motor efficiency, amperage, voltage phases and wiring diagrams. Identify the particular specification section number, paragraph and equipment identification number per equipment schedule. Note that suppliers (wholesalers and distributors) data sheets are not acceptable unless they are also manufacturers of the product being submitted.

L. Pump systems, with equipment in parallel, shall have performance curves noting single equipment operation and all iterations of additional equipment.

M. Certified Equipment Drawings (8-1/2" x 11" sheets) shall be indexed in accordance with Specification Section. Drawings to be submitted at a later date shall be marked with a page as a placeholder for insertion when submitted. The original submittal shall note which shop drawings will be submitted later. Marked-up catalogs are not acceptable and will be returned without action. Electronic submittal is required.

N. Engineer of Record’s review of submittals is for limited purpose of verifying conformance with information given and design concept expressed in Contract Drawings and Specifications. Engineer’s review is not for purpose of determining accuracy or completeness of items such as dimensions and quantities, which remain responsibility of Contractor.

O. Contractor shall not commence with fabrication or installation of any equipment or system until the associated submittals have been approved by the Engineer of Record and returned with "no exceptions" taken. Contractor shall be solely liable for any costs incurred from starting fabrication before approved submittals are returned.

P. All final approved submittals and equipment datasheets shall be provided, in PDF format, to the owner as part of the as-built drawing set and shall be text searchable.

1.06 COORDINATION DRAWINGS

A. Utilize the latest version of 3D AutoCAD, Navis works, and/or Revit software for the Coordination Drawings. No proprietary software of any kind shall be used other than that indicated. Drawing paper size shall not be larger than FULL SIZED Contract Drawings, and in no case larger than 30" x 42". Coordinate available space with ALL other trades involved.
B. Provide Coordination Drawings in digital electronic format. Provide both native file format (AutoCAD, Navisworks, or Revit) and PDF format files. Hardcopy drawings are not acceptable.

C. These drawings are to show pipe sizes, valves and accessories, elevation of bottom of pipe, all elevations of materials and/or systems throughout each floor inclusive of hanger components, seismic bracing if applicable, and any component of construction that impacts vertical and/or horizontal space. In addition, the locations of all valves and other items requiring access for service and maintenance are to be shown. The drawings are to also show electrical, structural beams, architectural bracing, structural bracing, ceiling heights, access doors, walls, floor to floor dimensions, columns, doors and other major architectural and structural features as shown on the architectural and structural drawings. Where the routing of work differs from that indicated on the Contract Drawings, such areas are to be indicated by highlighting with a note describing the reason for the change.

D. Rerouting of any system or part thereof shall be submitted separately in order to obtain concurrence of the Engineer of Record. Submitted rerouting must include fully documented proposed solutions with all trades coordinated. Contractor is fully responsible for coordination of systems included herein. Any effort by Engineer of Record beyond answering Contractor's questions will be at Contractor's expense, including attending coordination meetings, review of interim plans, or review of incomplete questions (routing issues without suggested solutions).

E. The Contractor and subcontractors are responsible to review and resolve any real or apparent interferences or conflicts as indicated by the coordination drawings produced by each trade.

F. After all conflicts or interferences are resolved, develop a final composite drawing showing the agreed upon routing, layout and juxtaposition of all piping, major conduit, valves, panels, lighting fixtures and all other major mechanical, plumbing and electrical installations. In the preparation of all the final Coordination Drawings, large scale details as well as cross and longitudinal sections are required to fully delineate all conditions.

G. Submit the Coordination Drawings as digital electronic files to Engineer of Record for review and comment, as indicated under “Shop Drawings” above. Coordination Drawings shall be digitally signed-off by all other trades.

H. Contractor shall not commence with fabrication or installation of any equipment or system until the associated shop drawings have been reviewed and returned by the Engineer of Record. Engineer's review of shop drawings shall not be taken as approval of their contents. Contractor shall be solely liable for any costs incurred due to deviations from the Contract Drawings.

I. No extra compensation will be paid for relocating any pipe, duct, conduit, or other material that has been installed without proper coordination between all trades involved. If any improperly coordinated work or installed work that is not in accordance with the approved coordination composites, or is specifically noted by the Architect or Engineer of Record for a valid reason, necessitates additional work by the other trades, the costs of all such additional work is to be borne solely by the Contractor.
J. All changes in the scope of work due to revisions formally issued and approved are to be shown on both the individual subcontractor's Shop Drawings and the Coordination Drawings.

1.07 REQUESTS FOR INTERPRETATION AND CLARIFICATION

A. See Division 01 “Project Management”, for RFI procedures and forms.

B. Plumbing RFIs are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Limit each RFI to a single issue or group of related issues.

D. Each RFI shall include a workable no-cost or lowest cost solution recommendation by Contractor.

E. Allow three (3) working days from time of RFI receipt by Engineer of Record for review and response.

F. Do not send Engineer of Record more than 10 RFIs in a contiguous period of 5 working days. If excess RFIs are received, review period will be extended as necessary to provide a professional response. RFIs will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.

1.08 MATERIALS AND SUBSTITUTIONS

A. Comply with Division 01 “Product Requirements”.

B. Requests for product or equipment substitution shall be accompanied by a marked up copy of the Engineer of Record’s original specification. For each specified product feature or requirement, Contractor shall note the equivalent feature or attribute of the proposed substitute product or equipment.

C. Shop drawings of proposed material and equipment that differ from the specified materials and equipment, shall be accompanied by drawings that define changes. These drawings shall show modifications of architectural, plumbing, electrical and mechanical work required by the proposed materials and equipment, such as relocation of flues, drains, revised electrical circuits, relocation of roof or wall penetrations, revised foundations, etc.

1.09 COORDINATION WITH OTHER WORK

A. Contractor performing Work under this Section shall become thoroughly familiar with the Drawings and Specifications. Contractor shall adjust the Work to conform with the conditions shown on these drawings to provide the best possible assembly of the combined Work.

B. Obtain necessary information from the other trades regarding location of their work in order that the Work in this Section may be placed in correct position.
C. The inclusion and proper location of supports, pads, sleepers, openings, anchorages, etc. provided by others is the responsibility of the Contractor under this Section. Cutting and/or boring shall be permitted under this Section only with the written approval of the Architect.

D. It shall be the Contractor's responsibility to coordinate and have provided by other trades where not covered by the Contractor's scope of work, all electrical wiring and power to equipment, controls and devices, and any other work from other trades as required to provide fully functioning plumbing systems per the Contract Drawings and Specifications.

1.10 MANUFACTURER’S DIRECTIONS

A. Manufacturer's directions shall be followed in cases where the manufacturers of articles used in this contract furnish directions covering points not shown in the Contract Drawings and Specifications.

1.11 PROTECTION OF WORK

A. Equipment and materials shall always be stored on dunnage and remain wrapped until installed.

B. Duct and piping shall be capped during delivery and storage.

C. During installation, all installed duct and piping shall be capped and protected at the end of each working day.

D. Equipment shall be protected from weather and stored in an enclosed, indoor location.

E. Until final acceptance of the work, protect materials from damage and provide adequate and proper storage facilities. Replace damaged or defective work, material, and equipment before requesting final acceptance.

1.12 WORKMANSHIP

A. Equipment and materials shall be installed in a neat and workmanlike manner. Materials and equipment not so installed shall, upon order of the Architect or Engineer of Record, be removed and replaced in a satisfactory manner, without change in Contract Sum or additional cost to the Owner.

1.13 CLOSING IN UNINSPECTED WORK

A. Do not allow or cause any work to be covered up or enclosed until it has been inspected, tested, and accepted by the Architect, Engineer of Record, and/or Commissioning Authority.

B. Any work enclosed or covered-up prior to inspection and testing shall be uncovered. After the work has been tested, inspected and accepted, repair such materials as may be necessary to restore disturbed work to its original and proper condition at no extra cost to the Owner.
1.14 EQUIPMENT ANCHORING
   A. Equipment shall be securely anchored to the building structure to prevent shifting or overturning during earthquakes.

1.15 PRELIMINARY OPERATION
   A. Under this section, Contractor shall supervise and direct preliminary operation of systems should the Owner demand that any portion of the plant, apparatus, or equipment be operated previous to the final completion and acceptance of the work. Expenses for such preliminary operation will be paid by the Owner. Such preliminary operation or payment shall not be construed as an acceptance of the work.

1.16 CUTTING AND OPENINGS
   A. Comply with Division 01 “Cutting and Patching”.

1.17 "AS-BUILT" DRAWINGS
   A. Comply with Section Division 01 “Project Closeout”.
   B. As-built drawings shall be furnished in an electronic format. Provide in drafting software (AutoCAD or Revit) native format and also in PDF format.

1.18 FINAL INSPECTION
   A. At the time of final inspection, a service representative shall be available to make final adjustments.

1.19 FINAL OPERATION
   A. After acceptance of the installation, instruct the Owner’s Representative in operation and maintenance, for a period of three (3), non-consecutive working days at a time requested by the Owner during the first year of warranty.
   B. At the beginning of the instruction period, deliver to the Owner three (3) copies of a durable binder as described under “Operating Instructions”.

1.20 OPERATING INSTRUCTIONS
   A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these Specifications.
   B. Division 22 shall compile and prepare documentation for all equipment and systems covered in Division 22 and deliver this documentation to the General Contractor for inclusion in the O&M manuals prior to the training of Owner personnel.
   C. Provide a summary of operating sequences (start-up, normal run, and shut-down), and control shop drawings in the main mechanical room.
D. Provide three (3) complete sets of Operating Instructions. These instructions shall include brochures, diagrams, maintenance, and operating instructions and parts lists. See Article 1.19 "Final Operation".

E. Provide a copy of the O&M manuals to the Commissioning Authority for review.

1.21 TRAINING OF OWNER PERSONNEL

A. The General Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The Commissioning Authority (CxA) shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

C. The Plumbing Contractor shall have the following training responsibilities:
   1. Provide the CxA with a training plan two weeks before the planned training.
   2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment including, but not limited to, pumps, heaters, controls, water treatment systems, etc.
   3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm, power failure, etc.
   4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
   5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
   6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
   7. Training shall include:
      a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
      b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
      c. Discussion of relevant health and safety issues and concerns.
      d. Discussion of warranties and guarantees.
      e. Common troubleshooting problems and solutions.
      f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
      g. Discussion of any peculiarities of equipment installation or operation.
Instruction in the use of equipment controls that are integral to equipment or are provided by the equipment manufacturer. Equipment controls training shall include at least the following:

1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system and any interface with security and communication systems.

2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

3) If system supports trending, all trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.

4) Every screen shall be completely discussed, allowing time for questions.

5) Use of keypad or plug-in laptop computer for mobile control access.

6) Use of remote access to the system via phone lines or networks, if applicable.

7) Graphics generation, if applicable.

8) Point database entry and modifications, if applicable


j. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate. A video record of the training session is suggested but not required.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

9. The Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

1.22 WARRANTY

A. In accordance with Division 01 Project Closeout requirements, Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. Contractor shall leave entire installation in complete working order and free from defects in material, workmanship, or finish.

C. Warranty all materials, equipment, apparatus, and workmanship to be free of defective materials and faulty workmanship for a minimum period of one (1) year from date of Certificate of Occupancy, or per Division 01, whichever is longer.
D. Warranty also services including instructions, adjusting, testing, noise, balancing, etc.

E. For each piece of equipment or device with a manufacturer’s warranty in excess of one year, Contractor shall furnish certificate of manufacturer’s warranty and contact information for manufacturer’s warranty service. Contractor shall also provide a list or table of all equipment with warranties exceeding one (1) year in duration.

F. Provide new materials, equipment, apparatus, labor and/or service, and support to correct or replace that determined by the Owner to be defective or faulty.

G. The Owner reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the guarantees or relieving responsibility during the guarantee period.

H. After a period of 90 calendar days from date of acceptance of systems by Owner, provide, at no cost to the Owner, one service mechanic for an 8-hour period over as many working days as required to repair, replace any latent deficiency.

END OF SECTION
SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer’s factory or shipped separately by equipment manufacturer for field installation.

1.03 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   1. Motor controllers.
   2. Torque, speed, and horsepower requirements of the load.
   3. Ratings and characteristics of supply circuit and required control sequence.
   4. Ambient and environmental conditions of installation location.

B. ACTION SUBMITTALS

1. Product Data: For each type of product.
   a. Delegated-Design Submittal: For each motor controllers, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
   b. Schedule: Indicate type, manufacturer’s number, size, material.

2. Sustainable Design Submittals:
   a. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   b. Green Building Material Certification Form (GBMCF):
      1) Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      2) All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.
2.02 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Motors for submersible pumps shall be hermetically sealed.

D. Motors 3/4 HP or greater shall be polyphase unless otherwise indicated.

E. Minimum Motor Service Factor: 1.15.

2.03 MOTOR ENCLOSURES

A. Totally Enclosed, Fan Cooled (TEFC) for motors located outdoors or in unconditioned or unventilated indoors areas unless otherwise indicated.

B. Open Dripproof (ODP) for other cases unless otherwise indicated.

2.04 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficiency, as defined in NEMA MG 1.

C. Polyphase motors shall be suitable for use with Variable-frequency Motor Controllers.

D. Construction:
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes to 1600 volts, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   3. Provide motor shaft grounding ring.
   5. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. Wiring Terminations:
   1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.05 SINGLE-PHASE MOTORS

A. Single-phase motors larger than 1/20 HP shall be Electronically Commutated (ECM) unless not offered by the manufacturer.
B. Electronically Commutated Motors (ECM)
   1. Motor shall be brushless DC type specifically designed for HVAC applications with heavy duty ball bearings and Electronic Commutation. It shall contain internal circuitry that converts single phase power into a DC signal. Speed control is achieved through a 0-10-volt DC control signal input through the pre-wired controls wires.
   2. The motor shall be speed controllable down to 20 percent of full speed and 85 percent efficient at all speeds.

C. Non-ECM
   1. Motors shall be one of the following, to suit starting torque and requirements of specific motor application (listed in order of preference):
      a. Permanent-split capacitor.
      b. Capacitor start, capacitor run.
      c. Capacitor start, inductor run.
      d. Split phase.
   2. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
   3. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION
SECTION 22 05 14
VARIABLE FREQUENCY DRIVES FOR EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. This Section includes solid-state, PWM, Variable Frequency Drives for speed control of three-phase, squirrel-cage induction motors.
   B. Related Sections include the following:
      1. Section 22 05 13 “Common Motor Requirements for Plumbing Equipment”.
      2. Division 26 for monitoring and control of motor circuits.

1.03 DEFINITIONS
   A. ASD: Adjustable Speed Drive.
   B. BAS: Building automation system.
   C. DDC: Direct digital control.
   D. EMI: Electromagnetic interference.
   E. IGBT: Insulated-gate bipolar transistor.
   F. LAN: Local area network.
   G. LED: Light-emitting diode.
   H. OCPD: Overcurrent protective device.
   I. PID: Control action, proportional plus integral plus derivative.
   J. PWM: Pulse-width modulated.
   K. RFI: Radio-frequency interference.
   L. VFC: Variable frequency controller.
   M. VFD: Variable frequency drive.
1.04 ACTION SUBMITTALS

A. See Division 01 and Section 22 00 00 “Plumbing General Requirements” for submittal procedures. May also be submitted as Variable-Frequency Controller (VFC), Adjustable Speed Drive (ASD), or similar.

B. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include short circuit interrupting capacities in compliance with Division 26.
   4. Include electrical power monitoring information in compliance with Division 26.

C. Shop Drawings: For each VFD indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include certification that VFD selection has been coordinated with equipment being served.
   5. Include ventilation means, points of connection, and air path.

D. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. Green Building Material Certification Form (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For each VFD, accessories, and components, from manufacturer.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.
D. Product Certificates: For each VFD from manufacturer.


F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Division 01 “Operation and Maintenance Data,” include the following:
      a. Manufacturer’s written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
      b. Manufacturer’s written instructions for testing, adjusting, and reprogramming microprocessor control modules.
      c. Manufacturer’s written instructions for setting field-adjustable timers, controls, and status and alarm points.
      d. Routine maintenance requirements for VFDs and all installed components.
      e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
      f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Indicating Lights: Two of each type and color installed.
   4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
   5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.08 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as
B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFDs covered and protected, in shipping splits of lengths that can be moved past obstructions in delivery path.

B. Store VFDs indoors on dunnage in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: 0 to 40 deg C.
   2. Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 1000 feet.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facility unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Owner’s Representative no fewer than 10 days in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary electrical service.
   3. Do not proceed with interruption of electrical service without Owner’s Representative’s written permission.

1.11 COORDINATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, control circuits, required control sequence, and duty cycle of motor and load.
1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. ABB Low Voltage Drives.
2. Eaton.
3. Or approved equal.

2.03 VARIABLE FREQUENCY DRIVES

A. Description: Variable-frequency motor drive / controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. IGBT, PWM; NEMA ICS 2, UL 508A listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design A and B, premium efficiency 3-phase induction motor by adjusting output voltage and frequency.
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

B. Application: Variable torque.

C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating:

1. Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range.
2. Maximum 208 voltage equals input voltage

E. Unit Operating Requirements:

1. Input AC Voltage Tolerance of 120 to 480V, plus or minus 15 percent.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance of 50/60 Hz, plus or minus 3 percent.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
7. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
8. Starting Torque: 100 percent of rated torque or as indicated.
9. Speed Regulation: Plus or minus 5 percent.
10. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

F. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

G. Isolated control interface to allow controller to follow control signal over a 40:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.

H. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to a minimum of 150 percent of maximum rating.

I. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
4. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
10. Short-circuit protection.
11. Motor overtemperature fault.

J. Automatic Reset/Restart: Attempts three restarts after fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to drive, motor, or load.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
M. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

N. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
2. Auxiliary contacts “a” and “b” arranged to activate with circuit-breaker handle.
3. Normally open alarm contact that operates only when circuit breaker has tripped.

2.04 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
3. Control Authority: Supports at least four conditions: Off, local manual control at VF

C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in drive door and connected to indicate the following parameters:
1. Output frequency (Hz).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).
E. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
   3. Output Signal Interface:
      a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
         1) Output frequency (Hz).
         2) Output current (load).
         3) DC-link voltage (VDC).
         4) Motor torque (percent).
         5) Motor speed (rpm).
         6) Set-point frequency (Hz).
         7) Instantaneous power consumption
   4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
      a. Motor running.
      b. Set-point speed reached.
      c. Fault and warning indication (overtemperature or overcurrent).
      d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

G. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMS control. Provide capability for VFD to retain these settings within the nonvolatile memory.

2.05 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer’s harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

2.06 BYPASS SYSTEMS

A. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
B. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

C. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker, with lockable handle.

D. Isolating Switch: Non-load-break switch arranged to isolate VFD and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.07 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type NEMA 3R.
   3. Other Wet or Damp Indoor Locations: Type NEMA 4.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as “Plenum Rated.”

2.08 ACCESSORIES

A. Devices shall be factory installed in enclosure, unless otherwise indicated.


C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

E. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

F. Supplemental Digital Meters:
   1. Elapsed-time meter.
   2. Kilowatt meter.
G. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Cooling Fan and Exhaust System: For NEMA 250; UL 508 component recognized: Supply fan, with intake and exhaust grills and filters.

J. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

K. Spare control-wiring terminal blocks; wired.

2.09 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.
   1. Test each VFD while connected to its specified motor.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

C. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.
3.03 INSTALLATION

A. VFDs to be mounted by Mechanical Contractor and connected by the Electrical Contractor unless noted otherwise. Electrical Contractor to confirm need for disconnect switch in addition to VFD and provide if necessary.

B. Free Standing: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to Unistrut or similar support system.

C. Floor-Mounting: Install on 6-inch nominal thickness concrete base.
   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

D. Roof-Mounting: Install on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

E. Comply with mounting and anchoring requirements specified in Division 26.

F. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

3.04 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.05 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility’s central-control system. Comply with requirements in Division 26.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.
3.06 CONNECTIONS

A. Conduit installation requirements are specified in Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFD element, bus, and component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

E. Tests and Inspections:
   1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
   5. Test each motor for proper phase rotation.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFD. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFD eleven (11) months after date of Substantial Completion.
      c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
   10. VFDs will be considered defective if they do not pass tests and inspections.
11. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.08 STARTUP SERVICE
A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer’s written instructions.

3.09 ADJUSTING
A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Construction Manager before increasing settings.
D. Set the taps on reduced-voltage autotransformer controllers.
E. Set field-adjustable circuit-breaker trip ranges as specified in Division 26.
F. Set field-adjustable pressure switches.

3.10 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION
SECTION 22 05 16
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Flexible-hose packless expansion joints.
   2. Metal-bellows packless expansion joints.
   3. Externally pressurized metal-bellows packless expansion joints.
   4. Rubber packless expansion joints.
   5. Grooved-joint expansion joints.
   6. Alignment guides and anchors.
   7. Pipe loops and swing connections.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer’s number, size, material, pressure rating, end connections, and location for each expansion joint.

C. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. Green Building Material Certification Form (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.
1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.06 QUALITY ASSURANCE


B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.03 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:

1. Manufacturer:
   a. Metraflex Company
   b. Mason Industries
   c. Or approved equal.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.

3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.

4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with threaded or soldered-joint end connections.
   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.

5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded or soldered-joint end connections.
   a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.

2.04 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturer:
a. Mason Industries, Inc  
b. Metraflex Company  
c. Or approved equal.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:
   1. Steel Shapes and Plates: ASTM A36/A36M.
   2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
   4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
   5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
      a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

PART 3 - EXECUTION

3.01 EXPANSION JOINT INSTALLATION
   
   A. Install expansion joints of sizes matching sizes of piping in which they are installed.
   
   B. Install metal-bellows expansion joints according to EJMA’s “Standards of the Expansion Joint Manufacturers Association, Inc.”
   
   C. Install rubber packless expansion joints according to FSA-PSJ-703.
   
   D. Install grooved-joint expansion joints to grooved-end steel piping.

3.02 PIPE LOOP AND SWING CONNECTION INSTALLATION
   
   A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
   
   B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
   
   C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
HMC Architects

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.03 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer’s written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION
SECTION 22 05 17
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Stack-sleeve fittings.
   3. Sleeve-seal systems.
   4. Sleeve-seal fittings.
   5. Escutcheons.
   7. Penetration Firestop
   8. Firestopping

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A53/A53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
C. Galvanized-Steel-Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.


E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.03 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.
   3. Or approved equal.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.04 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Link-Seal – GPT Industries.
   2. Metraflex Company (The)
   3. Or approved equal.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
   1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel, Plastic or Stainless steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating or Stainless steel of length required to secure pressure plates to sealing elements.

2.05 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. HOLDRITE.
   2. Link-Seal – GPT Industries.
   3. Or approved equal.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.
2.06 ESCUTCHEONS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. FERGUSON
   3. Or approved equal.

B. Description: Manufactured:
   1. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
   2. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.07 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 92 00 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.02 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 62 00 "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
   4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 84 13 "Penetration Firestopping."

3.03 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.04 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.05 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.

5. Interior Partitions:

3.06 ESCUTCHEONS INSTALATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

C. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   2. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   3. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
   4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   5. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   6. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   7. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
3.07 PENETRATION FIRESTOP

A. Fire-Rated Construction: Maintain barrier and structural floor fire resistance ratings including resistance to cold smoke at all penetrations, connections with other surfaces or types of construction, and sound or vibration absorption, and at other construction gaps.

B. Smoke Barrier Construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations, connections with other surfaces and types of construction and at all separations required to permit building movement and sound or vibration absorption, and at other construction gaps.

C. Systems or devices listed in the UL Fire Resistance Directory under categories XHCR and XHEZ may be used, providing that it conforms to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance, and that the system be symmetrical for wall applications. Systems or devices must be asbestos-free. Mortar systems must be Warnock Hersey approved.

D. Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the UL system or device, and designed to perform this function.

E. All firestopping products must be from a single manufacturer.

F. Through-penetration smokestopping at smoke partitions: Any system complying with the requirements for through-penetration firestopping in fire-rated construction, as specified, is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded in a non-fire rated smoke barrier.

G. Seal all pipe penetrations through fire-rated construction with factory-built devices or with manufactured fill, void, or cavity materials “Classified” by Underwriters Laboratories Inc. for use as a Through-Penetration Firestop. All firestop devices and systems shall be approved for such use by the Authority Having Jurisdiction. The firesafing system used shall maintain the fire-resistance rating of the building component that is penetrated.

H. All materials shall be non-hardening and non-toxic. The firesafing system used shall accommodate expansion and contraction of the floating plumbing piping systems without damaging the firestop or reducing its effectiveness as a smoke barrier or water seal.

3.08 FIRESTOPPING

A. Where space for future pipes and conduits is required, provide sleeves and fill with lightweight concrete or firestop.

B. Provide firestopping and grouting around pipes penetrating concrete slabs, concrete walls and masonry walls with cement grout in the sleeved opening extending full depth through wall or floor slab. Provide sheet metal cover over the insulation before applying grout. Around pipes through fire rated gypsum board construction, pack the annu-
lar space between the wall sleeve and the insulation sheet metal cover with noncombustible approved firestop material and finish with escutcheons on pipe where exposed. Attach escutcheons to wall.

C. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

D. Environmental Requirements:
1. Provide adequate ventilation if using solvent.
2. Provide forced-air ventilation during installation if required by manufacturer.
3. Keep flammable materials away from sparks or flame.
4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.
5. Comply with manufacturing recommendations for temperature and humidity conditions before, during and after installation of firestopping.

E. Clean surfaces that will be in contact with penetration seal materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

F. Install penetration seal materials in accordance with the UL Fire Resistance Directory or Mortars per Warnock Hersey approval and in accordance with manufacturer’s instructions.

G. Seal holes or voids made by penetrations to ensure an effective smoke barrier.

H. Where large openings are created in walls or floors to permit installation of pipes or other items, close unused portions of opening with firestopping material tested for the application. See UL Fire Resistance Directory or Warnock Hersey approvals.

END OF SECTION
SECTION 22 05 19

METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pressure gauges and pressure gauge taps.
   2. Thermometers
   3. Thermometer wells (thermowells).
   4. Test plugs and test-plug kits.
   5. Sight flow indicators.

B. Related Sections:
   1. Section 22 11 16 “Domestic Water Piping”.
   2. Division 25 for connecting meters to Building Management System (BMS).

1.03 REFERENCE STANDARDS

A. ASME B40.100 – Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2013.


1.04 ACTION SUBMITTALS

A. See Division 01 and 22 00 00 “Plumbing General Requirements” for submittal procedures.

B. Product Data: Provide table that indicates use, operating range, total range and location for manufactured components.

C. Project Record Documents: Record actual locations of components and instrumentation.

D. Sustainable Design Submittals:
1. **LEED Submittal Requirements**: Submit for Sustainability Consultant’s review.

2. **GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF)**:
   a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
   b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.05 **INFORMATIONAL SUBMITTALS**

A. Product Certificates: for each type of meter, gauge, thermowell, test plug, test plug kit, and slight flow indicator from manufacturer.

1.06 **CLOSEOUT SUBMITTALS**

A. Operation and Maintenance Data: for each type of meter, gauge, thermowell, test plug, test plug kit, and slight flow indicator to include in operation and maintenance manuals.

1.07 **MAINTENANCE MATERIAL SUBMITTALS**

A. Extra Temperature and Pressure Gauges: one of each type, range, and size.

1.08 **FIELD CONDITIONS**

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.01 **SUSTAINABILITY MATERIAL PERFORMANCE**

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 **PRESSURE GAUGES**

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Ashcroft Inc.
   2. Trerice, H. O. Co.
   3. Or approved equal.

B. Direct-Mounted, Dial-Type Pressure Gauges:
   1. ASME B40.100, UL 393 drawn steel or cast aluminum case, phosphor bronze bourdon tube, brass or stainless pressure connection with NPS 1/2 (DN 15) threads, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   2. Dial: Black scale on white background with etched scale markings graduated in psi (kPa).
   3. Size: 4-1/2-inch diameter.
   4. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
5. Provide dedicated isolation valve for each insertion well.

C. **Pressure gauge tappings:**
   1. **Gauge Cock:** Tee or lever handle, brass or stainless steel, NPS 1/2 connection for maximum 150 psig.
   2. **Needle Valve:** Brass or stainless steel, NPS 1/2 connection for minimum 150 psig.
   3. **Pulsation Damper:** Pressure snubber, brass, ASME B40.100, NPS 1/2 connection, include extensions for use on insulated piping where required.

**2.03 THERMOMETERS**

A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   1. Weksler AD.
   2. Weiss DVU
   3. Or approved equal.

B. Light-powered thermometer with solar panel and ½” LCD digital display. The light-powered thermometer can help reduce inventory requirements with its switchable °F and °C feature. The high impact ABS case can be adjusted for viewing from any angle. Stem lengths of 31/2” and 6” are available and are interchangeable with standard glass column industrial thermometers. The light-powered thermometer shall be digital type self-powered,
   1. **Switchable Range:** –40/300°F - –40/150°C
   2. **Accuracy:** 1% of reading or 1° whichever is greater
   3. **Display:** 1/2” LCD digits
   4. **Resolution:** 1/10° between –19.9/199.9°F or 28/93°C
   5. **Update Rate:** 10 seconds
   6. **Recalibration:** Internal potentiometer
   7. **Sensor:** Glass passivator thermistor
   8. **Lux Rating:** 10 Lux
   9. **Ambient Oper. Temp.** –30°F - 140°F
   10. **Ambient Temp. Error:** Zero
   11. **Humidity Rating:** 100%.

C. **Digital Vari-angle Thermometer** maintains the strict requirements for thermometers in hydronic applications in that they’re self-powered and within 1% accuracy. This reliable series of digital thermometers offers the added feature of stem assemblies for direct replacement of mercury-in-glass types where environmental concerns exist.
   1. **Case hi-impact abs**
   2. **Range** -50/300 °f -40/150 °c
   3. **Display** 1/2” lcd digits, wide ambient formula
   4. **Accuracy** 1% of reading or 1° whichever is greater
   5. **Resolution 1/10°** between -19.9/199.9 °f (-28/93 °c)
   6. **Recalibration internal potentiometer**
   7. **Lux rating 10 lux (one foot-candle)**
   8. **Update 10 seconds**
   9. **Ambient operating** -30/140 °f (-35/60 °c)
   10. **Sensor glass passivated thermistor**
D. Thermometer Supports:
1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
2. Flange: 3 inches outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.04 THERMOWELLS

A. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
2. Type: Stepped shank unless straight or tapered shank is indicated.
4. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
5. Internal Threads: 1/2, 3/4, and 1 inch with ASME B1.1 screw threads.
6. Bore: Diameter required to match thermometer bulb or stem.
7. Insertion Length: Length required to match thermometer bulb or stem.
8. Lagging Extension: Include on thermowell's internal screw thread to size of thermometer connection.
9. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
10. Strength: Thermowell shall be designed for a minimum of 35 FPS fluid velocity.

2.05 TEST PLUGS AND TEST PLUG KITS

A. Test Plugs: NPS 1/4 or NPS 1/2 brass or stainless fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene or EPDM core for 500 psig pressure rating at 200 deg F. Include extended stem where installed on insulated piping.

B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2-inch diameter pressure gauges, one-gauge adapters with 1/8-inch probes, two 1-inch dial thermometers.

2.06 SIGHT FLOW INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Emerson Process Management; Rosemount Division.
2. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
3. Pentair Valves & Controls; Penberthy Brand.

B. Description: Piping inline-installation device for visual verification of flow.
1. Construction: Bronze or stainless-steel body, with sight glass and ball indicator, and threaded or flanged ends.
3. Minimum Temperature Rating: 200 deg F.
4. End Connections for NPS 2 and Smaller: Threaded.
5. End Connections for NPS 2-1/2 and Larger: Flanged.
2.07 WATER FLOW METERS.

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Seametrics, Inc
   2. Badger Meter, Inc
   3. Honeywell Meter, Inc. similar to evoQ4
   4. Or approved equal.

B. Site utility Domestic Cold-Water meter by Civil. Part of DVC Art Building.

C. Building Domestic Cold Water Meter, Recycled Water Meter and Hot Water:
   1. Meters use a solid-state, long-lasting Hall- eVect sensor, which requires power. It is suited for use with Seametrics controls and metering pumps that have sensor power.
   2. Pulse Output: Meter sensor respond to a magnet that rotates on the face of the meter under the lens. The sensor turns on and off once each time the magnet passes under it. Sensors are designed for electronic control loads and should not be used to switch power loads or line voltages. See maximum current and voltage ratings, under Specifications.
   3. Every 0.5 seconds the measurement is taken and the totalized volume is calculated and updated on the LCD display.
   4. The meter is for use with potable cold water up to 105°F. The meter will typically register at +/-0.75% accuracy at normal and high flows and better than 95% accuracy at extended low flows.
   5. Reading Meter: The Total Flow that has passed through your meter is read by starting at the top of the register with the Six-Digit Totalizer, and then reading clockwise around the small dials. In the example below, the Six-Digit Totalizer reads 13,800 (138 x 100), and the dials read 60 (6 x 10), 2 (2 x 1), and .4 (4 x .1) respectively.
   6. AWWA C708 and C712 mechanical meters for utility billing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

C. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.

D. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

E. Install thermowells with extension on insulated piping.

F. Fill thermowells with heat-transfer medium.
G. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

H. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

I. Install valve and snubber in piping for each pressure gauge for fluids.

J. Locate test plugs adjacent to thermometers and thermometer sockets. Install test plugs in piping tees.

3.02 ADJUSTING

A. After installation, calibrate meters and gauges according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.03 GAUGE SCHEDULE

A. Unless noted otherwise, provide each gauge so that its range exceeds the full operating range of the system it is associated with by 1.5 to 2 times and so that the expected minimum and maximum operating points are within the gauge range.

END OF SECTION
SECTION 22 05 23
GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
1. Ball valves.
2. Butterfly valves.
3. Check valves.

B. Related Sections:
1. Section 22 11 16 “Domestic Water Piping”.
2. Section 22 13 16 “Sanitary Waste and Vent Piping”.
3. Section 22 14 13 “Storm Drainage Piping”.

1.03 DEFINITIONS
A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene-diene terpolymer rubber.
C. PTFE: Polytetrafluoroethylene.

1.04 ACTION SUBMITTALS
A. See Division 01 and Section 22 00 00 “Plumbing General Requirements” for submittal procedures.

B. Product Data: For each type of valve.
1. Certification that products that come into contact with potable water comply with NSF 61 Annex G and NSF 372.

C. Sustainable Design Submittals:
1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
   a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
   b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.
1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: for each type of valve to include in operation and maintenance manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, soldered ends, and grooves.
   4. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. Valves shall be manufactured in the United States.

C. Coordinate joint connection with Valve schedule in Part 3 and piping system specifications.

D. ASME Compliance:
   1. ASME B1.20.1 for threaded end valves.
   2. ASME B16.1 for flanges on iron valves.
   3. ASME B16.5 for flanges on steel valves.
   4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   6. ASME B31.9 for building service piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

G. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

H. Valve Actuator Types:
1. Gear Actuator: For valves NPS 8 and larger.

I. Valves in Insulated Piping: With 2-inch stem extensions; operating handles of non-thermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

J. All plumbing components including but not limited to valves and other wetted parts shall be lead free.

2.03 BALL VALVES

A. Two-Piece, Bronze Ball Valves with Full Port:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Apollo Valve
   c. Milwaukee Valve Company.
   d. Or approved equal.
2. Description: Two-Piece bronze body, chrome-plated brass ball, bronze trim, PTFE seat, steel handle with plated plastisol coating, 600 psig (4140 kPa) CWP rating.

B. Steel Ball Valves with Full Port:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. Or approved equal.
2. Description: Carbon steel (ASTM A216) split body, stainless steel ball and stem, PTFE seat.

2.04 BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Conbraco Industries, Inc.
   c. Or approved equal.
2. Description: Cast iron (ASTM A126) or ductile iron (ASTM A536) lug type body, suitable for bidirectional dead-end service at rated pressure without use of downstream flange, EPDM seat, one or two-piece stainless-steel stem, aluminum bronze disc.

3. Standard: MSS SP-67, Type I.

2.05 CHECK VALVES

A. Bronze, Swing Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. Or approved equal.

2. Description: Bronze (ASTM B62) body, spring loaded, bronze disc.


PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.02 INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 22 05 53 “Identification for Plumbing Piping and Equipment” for valve tags and schedules.
3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 VALVE SCHEDULE

A. Refer to piping system sections for valve schedules.

B. Coordinate Class or CWP rating with associated piping system rating.
   1. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

END OF SECTION
SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe positioning systems.
   7. Equipment supports.

B. Related Sections:
   1. Section 22 05 16 “Expansion Fittings and Loops for Plumbing Piping” for pipe guides and anchors.
   2. Section 22 05 48 “Vibration and Seismic Controls for Plumbing Piping and Equipment” for vibration isolation devices.

1.03 DEFINITIONS

A. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

1.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
   3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
1.05 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

D. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

2.03 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

B. Non-MFMA Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

2.04 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C533, Type I calcium silicate with 100-psig minimum compressive strength.

B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.05 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.06 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.07 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.08 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer’s operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating Below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: (12 inches) long and 0.048 inch thick.
   b. NPS 4: (12 inches) long and 0.06 inch thick.
   c. NPS 5 and NPS 6: (18 inches) long and 0.06 inch thick.
   d. NPS 8 to NPS 14: (24 inches long and 0.075 inch thick.
5. Pipes NPS 6 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.02 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
3.04 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 09 91 23 “Interior Painting.”

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.06 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and attachments for general service applications.

F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

G. Use padded hangers for piping that is subject to scratching.

H. Use thermal-hanger shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS.
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 2 4if little or no insulation is required.

3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS, to allow off-center closure for hanger installation before pipe erection.

4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS.

5. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS.

6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS.

7. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.

8. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

9. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

10. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

11. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

12. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

13. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg. F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg. piping installations.

L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. C-Clamps (MSS Type 23): For structural shapes.
3. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.

4. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed.
   3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   4. Constant Supports: For critical piping stress and if necessary, to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION
SECTION 22 05 48

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed-spring isolators.
5. Restrained-spring isolators.
6. Pipe-riser resilient supports.
7. Resilient pipe guides.
8. Elastomeric hangers.
9. Spring hangers.
10. Restraint channel bracings.
13. Mechanical anchor bolts.

B. Related Requirements:
1. Section 23 05 48 “Vibration and Seismic Controls for HVAC” for devices for HVAC equipment and systems.

1.03 DEFINITIONS


1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
   b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
   1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
   3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
   4. Seismic-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing’s. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
      c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
      d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.05 ACTION SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

E. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.


D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
      a. Component Importance Factor: 1.0.
      c. See structural sheet S1.01 and specification for other seismic design categories.

2.03 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation.
      b. Isolation Technology, Inc.
      c. Mason Industries, Inc.
      d. Or approved equal.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: elastomeric.
   a. Surface Pattern: Waffle pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.04 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch-thick neoprene.
   1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
   2. Maximum Load Per Support: 500 psig isolation material providing equal isolation in all directions.

2.05 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.
   1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.06 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line.
   2. Mason Industries.
   3. Unistrut.
   4. Or approved equal.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.07 RESTRAINT CABLES

A. Restraint Cables: ASTM A603 galvanized, ASTM A492 stainless-steel cables where exposed to weather or moisture. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.
2.08 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line
   2. Mason Industries
   3. Unistrut.
   4. Or approved equal.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.09 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line
   2. Mason Industries
   3. Hilti, Inc.
   4. Or approved equal.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.10 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hilti, Inc.
   2. Mason Industries
   3. Kinetic Noise Control,
   4. Or approved equal.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior appli-
cations and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. All piping attached to vibration isolated equipment shall also be isolated for the first 25 feet from the equipment with the same type of isolation as the equipment.

3.02 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.03 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 “Cast-in-Place Concrete.” and/or Section 03 30 53 “Miscellaneous Cast-in-Place Concrete.”

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 07 72 00 “Roof Accessories” for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.
E. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet and longitudinal supports a maximum of 80 feet.
   3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer’s recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 11 16 “Domestic Water Piping” for piping flexible connections.
3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test to 90 percent of rated proof load of device.
   7. Measure isolator deflection.
   8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.06 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION
SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Valve tags.
   5. Warning tags.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

F. Sustainable Design Submittals:
   1. LEED Sumbittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE
All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
   d. Or approved equal.
2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
4. Background Color: Black.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
   d. Or approved equal.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch-thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specifi-
2.03 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Marking Services Inc.
   c. Seton Identification Products.
   d. Or approved equal.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.


4. Background Color: Yellow.

5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.


9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include caution and warning information plus emergency notification instructions.

2.04 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
   d. Or approved equal.

2. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

3. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

4. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

5. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   a. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
b. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.05 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.
   4. Or approved equal.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.06 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.
   4. Or approved equal.

B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
   1. Size: 3 by 5-1/4 inches minimum.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as “DANGER,” “CAUTION,” or “DO NOT OPERATE.”

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.
3.02 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.03 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 09 91 23 "Interior Painting."

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units and at each valve. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 25 feet (7.6 m) along each run.
   8. On both sides of walls or partitions penetrated by piping.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:
   1. Domestic Water Piping
      a. Background: Safety green.
   2. Sanitary Waste and Storm Drainage Piping:
      a. Background Color: Safety black.
3.05 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
   2. Valve-Tag Colors:
   3. Letter Colors:

3.06 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION
SECTION 22 07 16
PLUMBING EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 01 81 13 “Sustainable Design Requirements” for additional Leadership in Energy and Environmental Design (LEED®) certification-related references, definitions, documentation requirements, action plans, meetings, and performance requirements of products and systems.

1.02 SUMMARY

A. Section includes insulating the following plumbing equipment:
   1. Domestic water, hot-water pumps.
   2. Domestic water, storage tanks.

B. Related Sections:
   1. Section 22 07 19 “Plumbing Piping Insulation.”

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant's review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail removable insulation at equipment connections and access panels.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.
   5. Detail field application for each equipment type.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
1. Sheet Form Insulation Materials: 12 inches square.
2. Sheet Jacket Materials: 12 inches square.
3. Manufacturer’s Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 “Hangers and Supports for Plumbing Piping and Equipment.”

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

1.08 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 INSULATION MATERIALS

A. Comply with requirements in “Domestic Water Storage Tank Insulation Schedule” and “Equipment Insulation Schedule” articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Industrial Insulation Group, LLC (IIG-LLC).
      b. Johns Manville

   2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type I. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

H. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. ROXUL
      b. Knauf Insulation.
      c. Johns Manville.

   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.
I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CertainTeed Corporation.
   b. Johns Manville; a Berkshire Hathaway company.
   c. Knauf Insulation.
   d. Owens Corning.

2.03 INSULATING CEMENTS


2.04 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.05 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a low VOC content for LEED IEQ Credit 4 requirement.
   2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over insulation.
   3. Service Temperature Range: 0 deg F to plus 180 deg F.

2.06 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: -40 deg F to plus 250 deg F.

2.07 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.08 FIELD-APPLIED FABRIC-REINFORCING MESH
A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for equipment.

2.09 FIELD-APPLIED JACKETS
A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
B. Metal Jacket:
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.

2.10 SECUREMENTS
A. Bands:
   1. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 3/4-inch-wide with wing seal.
B. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.

2.11 CORNER ANGLES
A. Aluminum Corner Angles: 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION
3.01 EXAMINATION
A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION
A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 deg F and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 deg F and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c. For below ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer’s written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
   5. Handholes.
   6. Cleanouts.

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   1. Apply adhesives according to manufacturer’s recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
   2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   3. Protect exposed corners with secured corner angles.
   4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
d. Do not over compress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer’s recommended adhesive.

2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from aluminum, at least 0.060 inch thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
3.05 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Domestic Water Heat Pump Breechings:
   1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
   3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer’s recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.08 FINISHES

A. Do not field paint aluminum or stainless-steel jackets.

3.09 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the “Equipment Insulation Schedule” Article. For large equipment, remove only a portion adequate to determine compliance.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
   1. Nominal density.

3.10 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor’s option.
B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Domestic hot-water circulation pump insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1 inch thick and 6-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1 inch thick and nominal density.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor’s option.

C. Equipment, Concealed:
   1. Aluminum, Smooth: 0.016 inch thick.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
   1. Aluminum, Smooth: 0.016 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
   1. Aluminum, Smooth with: 0.032 inch thick.

END OF SECTION
SECTION 22 07 19
PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 01 81 13 “Sustainable Design Requirements” for additional Leadership in Energy and Environmental Design (LEED®) certification-related references, definitions, documentation requirements, action plans, meetings, and performance requirements of products and systems.

1.02 SUMMARY

A. Section includes insulating the following plumbing piping services:
1. Domestic hot-water piping.
2. Domestic recirculating hot-water piping.
3. Roof drains and rainwater leaders.
4. Underground piping.
5. HVAC equipment condensate drain piping.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Sustainable Design Submittals:
1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
   a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
   b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties, equipment connections, and access panels.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1.06 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.07 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 05 29 “Hangers and Supports for Plumbing Piping and Equipment.”

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
1.08 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 INSULATION MATERIALS

A. Comply with requirements in “Piping Insulation Schedule, General,” “Indoor Piping Insulation Schedule,” “Outdoor, Aboveground Piping Insulation Schedule,” and “Outdoor, Underground Piping Insulation Schedule” articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. ROXUL
      b. Knauf Insulation.
      c. Johns Manville
      d. Or approved equal.
   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in “Factory-Applied Jackets” Article.

2.03 INSULATING CEMENTS

   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2.04 ADHESIVES
A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.05 SEALANTS
A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.06 FACTORY-APPLIED JACKETS
A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.07 FIELD-APPLIED FABRIC-REINFORCING MESH
A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.08 FIELD-APPLIED JACKETS
A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
B. Metal Jacket:
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.09 SECUREMENTS

A. Bands:
   1. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch-thick, 3/4-inch-wide with wing seal.

B. Wire: 0.080-inch nickel-copper alloy 0.062-inch soft-annealed, stainless steel 0.062-inch soft-annealed, galvanized steel.

2.10 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. InsUL Tect Products Co.
      b. Plumberex Specialty Products, Inc.
      c. Truebro.
      d. Or approved equal.
   2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
   4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   1. Seal penetrations with flashing sealant.
   2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 07 84 13 “Penetration Firestopping” for firestopping and fire-resistant joint sealers.

E. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 84 13 “Penetration Firestopping.”

3.05 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
   6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. Stencil or label the outside insulation jacket of each union with the word “union.” Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
   2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
   3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
   4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
   5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.06 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
   4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer’s recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.07 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.08 FINISHES

A. Do not field paint aluminum or stainless-steel jackets.

3.09 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the “Piping Insulation Schedule, General” Article.
D. All insulation applications will be considered defective work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   1. Drainage piping located in crawl spaces.
   2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

C. Cathodic Protection for Underground piping:
   1. Sanitary Waste and Vent piping shall be completed with Section 22 13 16 and soil corrosive protection requirements.
   2. Storm Drainage piping shall be completed with Section 22 14 13 and soil corrosive protection requirements.
   3. Domestic Water piping shall be completed with Section 22 11 16 and soil corrosive protection requirements.
   4. Recycled Water piping shall be completed with Section 22 11 16 and soil corrosive protection requirements.

D. Domestic Hot and Recirculated Hot Water Temperature Range (105 to 140 deg F):
   1. NPS less than 1 inch: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   2. NPS 1 inch Larger: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2" thick.

E. Storm water and Overflow:
   1. All Pipe Sizes: Insulate horizontal roof drainage piping and first 18 inches of vertical riser. Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

F. Roof Drain and Overflow Drain Bodies:
   1. All Pipe Sizes: Insulate roof and overflow drain bodies and vertical drop to horizontal piping. Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

G. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

H. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

I. HVAC Equipment Condensate Drains pipings:
1. NPS less than 1 inch: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 0.5 inch thick.
2. NPS 1 inch Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor’s option.

C. Piping, Concealed:
   1. None.
   2. Aluminum, Smooth: 0.016 inch thick.

D. Piping, Exposed:
   1. Aluminum, Smooth: 0.016 inch thick.

END OF SECTION
SECTION 22 11 16
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
   2. Encasement for piping.

B. Related Requirements:
   1. Section 01 81 13 “Sustainability and LEED – V4 Requirements” for sustainability requirements.
   2. Section 22 05 19 – Meters and Gauges for Plumbing Piping.
   3. Section 22 05 23 – General Duty Valves for Plumbing Piping.
   5. Division 31 for earth moving.

1.03 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. System purging and disinfecting activities report.

1.04 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
B. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Field Conditions:
   1. Pipe shall be transported to the site in enclosed vehicles or with ends covered.
   2. Do not store pipe directly on ground or floor.
   3. Pipe stored or stacked on site shall be covered.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Domestic Water Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Construction Manager’s written permission.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in “Piping Schedule” Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All materials that come into contact with potable water shall be lead free.

C. All materials specified in this section shall be manufactured in the United States.

D. Sustainability Material Performance:
   1. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 COPPER TUBE AND FITTINGS

A. Above Grade Inside Building – Hard Copper Tube: ASTM B88, Type L water tube, drawn temper.

B. Below Grade Inside Building – Soft Copper Tube: ASTM B88, Type K water tube, annealed temper.


D. Copper Unions:
   1. MSS SP-123.
4. Solder-joint or threaded ends.

E. Appurtenances for Grooved-End Copper Tubing:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Grinnell Mechanical Products.
      c. Victaulic Company.
   2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B75 copper tube or ASTM B584 bronze castings.
   3. Mechanical Couplings for Grooved-End Copper Tubing:
      a. Copper-tube dimensions and design similar to AWWA C606.
      b. EPDM-rubber gaskets suitable for hot and cold water.
      c. Bolts and nuts.
      d. Minimum Pressure Rating: 300 psig.

2.03 DUCTILE-IRON PIPE AND FITTINGS UNDERGROUND OUTSIDE OF THE BUILDING

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:
   1. AWWA C110/A21.10, ductile or gray iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:
   1. AWWA C153/A21.53, ductile iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.


E. Appurtenances for Grooved-End, Ductile-Iron Pipe:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Victaulic Company.
   2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions that match pipe.
   3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:
      a. AWWA C606 for ductile-iron-pipe dimensions.
      b. EPDM-rubber gaskets suitable for hot and cold water.
      c. Bolts and nuts.
      d. Minimum Pressure Rating:
         1) NPS 14 to NPS 18: 250 psig.
         2) NPS 20 to NPS 46: 150 psig.
2.04 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
   1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
   2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.05 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Dresser, Inc.
      c. Romac Industries, Inc.

2.06 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Wilkins.
      c. Zurn Industries, LLC.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 125 psig minimum at 180 deg F.
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
C. Dielectric Nipples: 6” red brass nipple.

2.07 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND METAL PIPING AND COUPLINGS OUTSIDE THE BUILDING AND BELOW BUILDING (DUCTILE IRON AND COPPER PIPING).

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material:
   1. Linear low-density polyethylene film of 0.008-inch minimum thickness.
   2. Direct buried ductile iron pipe should be encased in 8-mil polyethylene as specified in AWWA specification C-105. Epoxy coatings are also an acceptable alternative type of coating system for the pipe and/or fittings such as valves.
   3. All rubber gasket joints, fusion-bonded epoxy coated flanges and flexible couplings on ductile iron pipelines should be bonded with insulated copper cable to insure electrical continuity of the pipeline and fittings.
   4. Insulating flanges and/or couplings should be installed to electrically isolate the buried portion of pipeline from other metallic pipelines, reinforced concrete structures and above grade buildings or structures.
   5. Test stations shall be installed on all ductile iron pipelines at a spacing of 800 to 1,000 feet. Bonding and test stations shall comply with NACE Standards.
   6. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the entire length of buried metallic pipeline. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.08 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND FITTING OUTSIDE THE BUILDING AND BELOW BUILDING (DUCTILE IRON AND COPPER PIPING).

A. All direct buried ductile iron fittings installed on non-metallic piping shall be provided with a bituminous coating from the factory and encased in an 8-mil polyethylene bag in the field in accordance with AWWA Specification C-105. All bolts, restraining rods, etc. shall be coated with bitumastic prior to encasement in the polyethylene bag.

B. All metallic valves shall be coated from the factory (i.e. using powdered epoxy or equivalent type of coating system) and all bolts shall be coated with bitumastic in the field and the entire valve shall be encased in an 8-mil polyethylene bag in accordance with AWWA Specification C-105.

C. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the valves and fittings. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.09 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND COPPER WATER PIPELINES (SERVICE LINES)

A. All copper water laterals shall be provided with a 6-mil polyethylene sleeve to effectively isolate the copper piping from the earth.
B. All copper water laterals shall be electrically isolated from metallic water mains via the use of insulating type corporation stops installed at the water main.

PART 3 - EXECUTION

3.01 EARTH MOVING
   A. Comply with requirements in Division 31 for excavating, trenching, and backfilling.

3.02 PIPING INSTALLATION
   A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
   B. Install copper tubing under building slab according to CDA’s “Copper Tube Handbook.”
   C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
   D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 05 19 “Meters and Gages for Plumbing Piping” and with requirements for drain valves and strainers in Section 22 11 19 “Domestic Water Piping Specialties.”
   E. Install shutoff valve immediately upstream of each dielectric fitting.
   F. Install shutoff valve immediately upstream and downstream of each water meter.
   G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 11 19 “Domestic Water Piping Specialties.”
   H. Install domestic water piping at the minimum slopes indicated on drawings.
   I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices.
   J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
   K. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping for each plumbing pump. Comply with requirements for pressure gages in Section 22 05 19 “Meters and Gages for Plumbing Piping.”

S. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 11 23 “Domestic Water Pumps.”

T. Install pressure gauge on the incoming service for each building. Comply with requirements for pressure gages in Section 22 05 19 “Meters and Gages for Plumbing Piping.”

U. Install thermometers on inlet and outlet piping from each water heater and Air Source Heat Pumps. Comply with requirements for thermometers in Section 22 05 19 “Meters and Gages for Plumbing Piping.”

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals requirements.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

3.03  JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA’s “Copper Tube Handbook,” “Brazed Joints” chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA’s “Copper Tube Handbook.”

F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

G. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

I. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.04 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.05 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 4 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 5 and Larger: Use dielectric flanges.

3.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices requirements.

B. Comply with requirements for pipe hanger, support products, and installation,
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
   3. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
4. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
5. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
7. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of \( \frac{3}{8} \) inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with \( \frac{3}{8} \)-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with \( \frac{3}{8} \)-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with \( \frac{3}{8} \)-inch rod.
   4. NPS 2-1/2: 108 inches with \( \frac{1}{2} \)-inch rod.
   5. NPS 3 to NPS 5: 10 feet with \( \frac{1}{2} \)-inch rod.
   6. NPS 6: 10 feet with \( \frac{5}{8} \)-inch rod.
   7. NPS 8: 10 feet with \( \frac{3}{4} \)-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with \( \frac{3}{8} \)-inch rod.
   2. NPS 1-1/2: 108 inches with \( \frac{3}{8} \)-inch rod.
   3. NPS 2: 10 feet with \( \frac{3}{8} \)-inch rod.
   4. NPS 2-1/2: 11 feet with \( \frac{1}{2} \)-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with \( \frac{1}{2} \)-inch rod.
   6. NPS 4 and NPS 5: 12 feet with \( \frac{5}{8} \)-inch rod.
   7. NPS 6: 12 feet with \( \frac{3}{4} \)-inch rod.
   8. NPS 8 to NPS 12: 12 feet with \( \frac{7}{8} \)-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with \( \frac{3}{8} \)-inch rod.
   2. NPS 1-1/2: 108 inches with \( \frac{3}{8} \)-inch rod.
   3. NPS 2: 10 feet with \( \frac{3}{8} \)-inch rod.
   4. NPS 2-1/2: 11 feet with \( \frac{1}{2} \)-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with \( \frac{1}{2} \)-inch rod.
   6. NPS 4 and NPS 5: 12 feet with \( \frac{5}{8} \)-inch rod.
   7. NPS 6: 12 feet with \( \frac{3}{4} \)-inch rod.
   8. NPS 8 to NPS 12: 12 feet with \( \frac{7}{8} \)-inch rod.

3.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   2. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.08 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation requirements

B. Label pressure piping with system operating pressure.

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in “Piping Tests” Subparagraph below and to ensure compliance with requirements.
      c. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.

2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.

4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.


7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.

8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:
   1. Soft copper tube, ASTM B88, Type K; wrought-copper,
   2. Fittings:
      b. Wrought copper solder type pressure fittings complying with ASME B16.22.
   3. Field wrap with 50-mil PVC tape or factory-applied PVC coating.
   4. Joints: Brazed using AWS A5.8/A5.8M, AWS BCuP Series, copper-phosphorus alloys, unless otherwise indicated; equivalent to:
      a. “Stay-Silv 15” by Harris Products Group
      b. “Sil-Can 15” by Canfield

D. Under-building-slab, domestic water, building-service piping, NPS 4 and larger, shall be one of the following:
      a. Interior of Pipe: Cement-lined and seal coated, AWWA C104/A21.4 and listed by approved certifying agency as conforming to requirements of NSF/ANSI 61.
   2. Fittings: Mechanical joint ductile iron fittings: Complying with applicable requirements of ANSI/AWWA C110/A21.10 and ANSI/AWWA C111/A21.11 with exception of manufacturer’s proprietary design dimensions, 350 psi working pressure rating, and flexible restrained joint ductile iron components in accordance with ANSI/AWWA C110/A21.10.
      a. Inside of Fittings: Cement-lined and seal coated, ANSI/AWWA C104/A21.4 and listed by approved certifying agency as conforming to requirements of NSF/ANSI 61.

E. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:
1. Hard copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
   a. Fittings:
      1) Cast copper alloy complying with ASME B16.18.
      2) Wrought copper solder type pressure fittings complying with ASME B16.22.
      3) Class 150, flat-faced, flanges complying with ASME B16.24.
   b. Joints:
      1) 1½ inch to ½ inches: Soldered using ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813. 100 percent lead free, 95 percent tin and 5 percent antimony composition, silver bearing solders, unless otherwise indicated; equivalent to:
         a) “Silverflo” by Canfield
         b) “Bridgit” by Harris Products Group

F. Aboveground domestic water piping, NPS 2-1/2 and larger shall be one of the following:
1. Hard copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
2. Hard copper tube, ASTM B88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.
   a. Fittings:
      1) Cast copper alloy complying with ASME B16.18.
      2) Wrought copper solder type pressure fittings complying with ASME B16.22.
      3) Class 150, flat-faced, flanges complying with ASME B16.24.
   b. Joints:
      1) 2 inches and larger: Brazed using AWS A5.8/A5.8M, AWS BCuP Series, copper-phosphorus alloys, unless otherwise indicated; equivalent to:
         a) “Stay- Silv 15” by Harris Products Group
         b) “Sil-Can 15” by Canfield.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
SECTION 22 11 17

RECYCLED WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground Recycled water pipes, tubes, and fittings inside buildings.
   2. Encasement for piping.

B. Related Requirements:
   1. Section 01 81 13 "Sustainability and LEED – NC V4 Requirements" for sustainability requirements.
   2. Section 22 05 19 – Meters and Gauges for Plumbing Piping.
   3. Section 22 05 23 – General Duty Valves for Plumbing Piping.
   5. Division 31 for earth moving.

1.03 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. System purging and disinfecting activities report.

1.04 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.
1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Field Conditions:
   1. Pipe shall be transported to the site in enclosed vehicles or with ends covered.
   2. Do not store pipe directly on ground or floor.
   3. Pipe stored or stacked on site shall be covered.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Recycled Water Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of water service.
   2. Do not proceed with interruption of water service without Construction Manager’s written permission.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Comply with requirements in “Piping Schedule” Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All materials that come into contact with potable water shall be lead free.

C. All materials specified in this section shall be manufactured in the United States.

D. Sustainability Material Performance
   1. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 COPPER TUBE AND FITTINGS

A. Above Grade Inside Building – Hard Copper Tube: ASTM B88, Type L water tube, drawn temper.

B. Below Grade Inside Building – Soft Copper Tube: ASTM B88, Type K water tube, annealed temper.


D. Copper Unions:
   1. MSS SP-123.
   4. Solder-joint or threaded ends.
E. Appurtenances for Grooved-End Copper Tubing:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International.
      b. Grinnell Mechanical Products.
      c. Victaulic Company.
   2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B75 copper tube or ASTM B584 bronze castings.
   3. Mechanical Couplings for Grooved-End Copper Tubing:
      a. Copper-tube dimensions and design similar to AWWA C606.
      b. EPDM-rubber gaskets suitable for hot and cold water.
      c. Bolts and nuts.
      d. Minimum Pressure Rating: 300 psig.

2.03 DUCTILE-IRON PIPE AND FITTINGS UNDERGROUND OUTSIDE OF THE BUILDING

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:
   1. AWWA C110/A21.10, ductile or gray iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:
   1. AWWA C153/A21.53, ductile iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.


E. Appurtenances for Grooved-End, Ductile-Iron Pipe:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Victaulic Company.
   2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions that match pipe.
   3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:
      a. AWWA C606 for ductile-iron-pipe dimensions.
      b. EPDM-rubber gaskets suitable for hot and cold water.
      c. Bolts and nuts.
      d. Minimum Pressure Rating:
         1) NPS 14 to NPS 18: 250 psig.
         2) NPS 20 to NPS 46: 150 psig.

2.04 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.05 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Dresser, Inc.
      c. Romac Industries, Inc.

2.06 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Watts; a Watts Water Technologies company.
      b. Wilkins.
      c. Zurn Industries, LLC.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 125 psig minimum at 180 deg F.
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples: 6” red brass nipple.
2.07 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND METAL PIPING AND COUPLINGS OUTSIDE THE BUILDING AND BELOW BUILDING (DUCTILE IRON AND COPPER PIPING).

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material:
1. Linear low-density polyethylene film of 0.008-inch minimum thickness.
2. Direct buried ductile iron pipe should be encased in 8-mil polyethylene as specified in AWWA specification C-105. Epoxy coatings are also an acceptable alternative type of coating system for the pipe and/or fittings such as valves.
3. All rubber gasket joints, fusion-bonded epoxy coated flanges and flexible couplings on ductile iron pipelines should be bonded with insulated copper cable to insure electrical continuity of the pipeline and fittings.
4. Insulating flanges and/or couplings should be installed to electrically isolate the buried portion of pipeline from other metallic pipelines, reinforced concrete structures and above grade buildings or structures.
5. Test stations shall be installed on all ductile iron pipelines at a spacing of 800 to 1,000 feet. Bonding and test stations shall comply with NACE Standards.
6. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the entire length of buried metallic pipeline. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.08 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND FITTINGS OUTSIDE THE BUILDING AND BELOW BUILDING (DUCTILE IRON AND COPPER PIPING).

A. All direct buried ductile iron fittings installed on non-metallic piping shall be provided with a bituminous coating from the factory and encased in an 8-mil polyethylene bag in the field in accordance with AWWA Specification C-105. All bolts, restraining rods, etc. shall be coated with bitumastic prior to encasement in the polyethylene bag.

B. All metallic valves shall be coated from the factory (i.e. using powdered epoxy or equivalent type of coating system) and all bolts shall be coated with bitumastic in the field and the entire valve shall be encased in an 8-mil polyethylene bag in accordance with AWWA Specification C-105.

C. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the valves and fittings. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.09 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND COPPER WATER PIPELINES (SERVICE LINES)

A. All copper water laterals shall be provided with a 6-mil polyethylene sleeve to effectively isolate the copper piping from the earth.

B. All copper water laterals shall be electrically isolated from metallic water mains via the use of insulating type corporation stops installed at the water main.
PART 3 - EXECUTION

3.01 PIPE MATERIAL / PIPE IDENTIFICATION

A. RECYCLED water piping and fittings shall be as required in this Code for potable-water piping and fittings. All RECYCLED water pipe and fittings shall be continuously wrapped with purple Mylar tape. The wrapping tape shall have a minimum nominal thickness of 0.0005 inches and a minimum width of 2 inches. Tape shall be fabricated of polyvinyl chloride with a synthetic rubber adhesive and a clear polypropylene protective coating or approved equal. The tape shall be purple (Pantone color #512) and shall be imprinted in nominal ½ inch high, black, uppercase letters, with the words “CAUTION: RECYCLED WATER, DO NOT DRINK”. The lettering shall be imprinted in two (2) parallel lines, such that after wrapping the pipe with a ½-width overlap, one (1) full line of text shall be visible. Wrapping tape is not required for buried PVC pipe manufactured with purple color integral to the plastic and marked on opposite sides to read “CAUTION: RECYCLED WATER, DO NOT DRINK” in intervals not to exceed 3 feet. All valves, except fixture supply control valves, shall be equipped with a locking feature. All mechanical equipment, which is appurtenant to the RECYCLED water system, shall be painted purple to match the Mylar wrapping tape.

3.02 SIGNS

A. Room Entrance Signs: All installations using RECYCLED water for water closets and/or urinals shall be identified with signs. Each sign shall contain ½ inch letters of a highly visible color on a contrasting background. The location of the sign(s) shall be such that the sign(s) shall be visible to all users. The number and location of the signs shall be approved by the Administrative Authority and shall contain the following text:

TO CONSERVE WATER,
THIS BUILDING USES RECYCLED WATER
TO FLUSH TOILETS AND URINALS.

B. Equipment Room Signs: Each equipment room containing RECYCLED water equipment shall have a sign posted with the following wording in 1-inch letters on a purple background:

CAUTION:
RECYCLED WATER – DO NOT DRINK.
DO NOT CONNECT TO DRINKING WATER SYSTEM.

NOTICE:
CONTACT BUILDING MANAGEMENT BEFORE PERFORMING ANY WORK ON
THIS RECYCLED WATER SYSTEM.

This sign shall be posted in a location that is visible to anyone working on or near recycled water equipment.
1. Where tank-type water closets are flushed with recycled water, the tank shall be labeled:

**RECYCLED WATER – DO NOT DRINK.**

2. Valve Access Door Signs: Each recycled water valve within a wall shall have its access door into the wall equipped with a warning sign approximately 6 inches by 6 inches with wording in ½ inch letters on a purple background. The size, shape and format of the sign shall be substantially the same as that specified in Clause B. above. The signs shall be attached inside the access doorframe and shall hang in the center of the access doorframe. This sign requirement shall be applicable to any and all access doors, hatches, etc. leading to recycled water piping and appurtenances.

3.03 VALVE SEALS

A. Each valve or appurtenance shall be sealed in a manner approved by the Administrative Authority after the RECYCLED system has been approved, and placed into operation. These seals shall either be a crimped lead wire seal, or a plastic breakaway seal which, if broken after system approval, shall be deemed conclusive evidence that the RECYCLED water system has been accessed. The seals shall be purple with the words “RECYCLED WATER”, and shall be supplied by the RECYCLED water purveyor, or by other arrangements acceptable to the Administrative Authority.

PART 4 - EXECUTION

4.01 EARTH MOVING

A. Comply with requirements in Division 31 for excavating, trenching, and backfilling.

4.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of Recycled water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA’s “Copper Tube Handbook.”

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each Recycled water-service entrance. Comply with requirements for pressure gages in Section 22 05 19 “Meters and Gages for Plumbing Piping” and with requirements for drain valves and strainers in Section 22 11 19 “Recycled Water Piping Specialties.”

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install shutoff valve immediately upstream and downstream of each water meter.
G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 11 19 “Recycled Water Piping Specialties.”

H. Install Recycled water piping at the minimum slopes indicated on drawings.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices.

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gauge on the incoming service for each building. Comply with requirements for pressure gages in Section 22 05 19 “Meters and Gages for Plumbing Piping.”

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals requirements.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

4.03 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA’s “Copper Tube Handbook,” “Brazed Joints” chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA’s “Copper Tube Handbook.”

F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

G. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for Recycled water service. Join flanges with gasket and bolts according to ASME B31.9.

I. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

4.04 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Recycled Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

4.05 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 4 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 5 and Larger: Use dielectric flanges.
4.06 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices requirements.

B. Comply with requirements for pipe hanger, support products, and installation,
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
   3. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   4. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
   5. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   7. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.

H. Install supports for vertical steel piping every 15 feet.

I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.

4.07 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.
B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect Recycled water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect Recycled water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Plumbing Fixtures: Recycled water-supply piping in sizes indicated, but not smaller than that required by plumbing code.

4.08 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation requirements

B. Label pressure piping with system operating pressure.

4.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in “Piping Tests” Subparagraph below and to ensure compliance with requirements.
      c. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill Recycled water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced Recycled water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Recycled water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

4.10 ADJUSTING

A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

4.11 CLEANING

A. Clean and disinfect potable Recycled water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
C. Clean interior of Recycled water piping system. Remove dirt and debris as work progresses.

4.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, Recycled water, building-service piping, NPS 3 and smaller, shall be the following:
   1. Soft copper tube, ASTM B88, Type K; wrought-copper,
   2. Fittings:
      b. Wrought copper solder type pressure fittings complying with ASME B16.22.
   3. Field wrap with 50-mil PVC tape or factory-applied PVC coating.
   4. Joints: Brazed using AWS A5.8/A5.8M, AWS BCuP Series, copper-phosphorus alloys, unless otherwise indicated; equivalent to:
      a. “Stay-Silv 15” by Harris Products Group
      b. “Sil-Can 15” by Canfield

D. Under-building-slab, Recycled water, building-service piping, NPS 4 and larger, shall be one of the following:
      a. Interior of Pipe: Cement-lined and seal coated, AWWA C104/A21.4 and listed by approved certifying agency as conforming to requirements of NSF/ANSI 61.
   2. Fittings: Mechanical joint ductile iron fittings: Complying with applicable requirements of ANSI/AWWA C110/A21.10 and ANSI/AWWA C111/A21.11 with exception of manufacturer’s proprietary design dimensions, 350 psi working pressure rating, and flexible restrained joint ductile iron components in accordance with ANSI/AWWA C110/A21.10.
      a. Inside of Fittings: Cement-lined and seal coated, ANSI/AWWA C104/A21.4 and listed by approved certifying agency as conforming to requirements of NSF/ANSI 61.
E. Aboveground Recycled water piping, NPS 2 and smaller, shall be the following:
   1. Hard copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
      a. Fittings:
         1) Cast copper alloy complying with ASME B16.18.
         2) Wrought copper solder type pressure fittings complying with ASME B16.22.
         3) Class 150, flat-faced, flanges complying with ASME B16.24.
      b. Joints:
         1) 1½ inch to ½ inches: Soldered using ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813. 100 percent lead free, 95 percent tin and 5 percent antimony composition, silver bearing solders, unless otherwise indicated; equivalent to:
            a) “Silverflo” by Canfield
            b) “Bridgit” by Harris Products Group

F. Aboveground Recycled water piping, NPS 2-1/2 and larger shall be one of the following:
   1. Hard copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
   2. Hard copper tube, ASTM B88, Type L; grooved-joint, copper-tube appurtenances; and grooved joints.
      a. Fittings:
         1) Cast copper alloy complying with ASME B16.18.
         2) Wrought copper solder type pressure fittings complying with ASME B16.22.
         3) Class 150, flat-faced, flanges complying with ASME B16.24.
      b. Joints:
         1) 2 inches and larger: Brazed using AWS A5.8/A5.8M, AWS BCuP Series, copper-phosphorus alloys, unless otherwise indicated; equivalent to:
            a) “Stay- Silv 15” by Harris Products Group
            b) “Sil-Can 15” by Canfield

4.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.

B. Use check valves to maintain correct direction of Recycled water flow to and from equipment.

END OF SECTION
SECTION 22 11 19
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   2. Thermostatic Water Mixing Valves
   3. Strainers.
   4. Outlet boxes.
   5. Hose bibbs.
   6. Wall hydrants.
   7. Drain valves.
   8. Water-hammer arrestors.
   9. Air vents.
   10. Trap-seal primer devices.
   11. Flexible connectors.
   12. Aquastat controller and timer.

B. Related Requirements:
   1. Section 01 81 13 “Sustainability and LEED – V4 Requirements” for sustainability requirements.
   2. Section 22 05 19 “Meters and Gauges for Plumbing Piping” for thermometers, pressure gauges, and flow meters in domestic water piping.
   3. Section 22 11 16 “Domestic Water Piping”.
   4. Section 22 42 00 “Plumbing Fixtures” for water tempering equipment.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.
   1. Include diagrams for power, signal, and control wiring.
   2. Sustainable Design Submittals:
      a. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
      b. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
         1) Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
         2) All products must comply with LEED + WELL Material Performance Requirements per Section 018120.
1.04 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For domestic water piping specialties to include in
emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE
A. Domestic piping specialties shall bear label, stamp, or other markings of specified test-
ing agency.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE
A. All products must comply with LEED + WELL material performance requirements per
section 18120.

2.02 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES
A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.
B. All plumbing components including but not limited to valves, strainers, backflow pre-
venters and other wetted parts shall be lead free.
C. Domestic water piping specialties shall be manufactured in the United States.
D. Backflow preventers shall be listed with Foundation for Cross-Connection Control and
Hydraulic Research at the University of Southern California.

2.03 PERFORMANCE REQUIREMENTS
A. Minimum Working Pressure for Domestic/Recycled Water Piping Specialties:
(125 psig) unless otherwise indicated.

2.04 BALANCING VALVES
A. Copper-Alloy Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by
      one of the following:
      a. Bell & Gossett.
      b. Watts; a Watts Water Technologies company.
      c. Or approved equal.
   2. Type: Ball valve with two readout ports and memory-setting indicator.
   3. Body: Brass or bronze.
   4. Size: Same as connected piping, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carry-
ing case.
B. Cast-Iron Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by
      one of the following:
a. NIBCO INC.
2. Watts; a Watts Water Technologies company.
3. Or approved equal.
4. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
5. Size: Same as connected piping, but not smaller than NPS 2-1/2.
6. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. NIBCO INC.
   c. Or approved equal.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.

2.05 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Master Water Tempering Valves (TMV-1):
2. Type TM Thermostatic water mixing valve, adjustable high temperature limit stop*, inlet check-stops, wall support, outlet ball valve
3. Small Type TM Thermostatic water mixing valve, adjustable high temperature limit stop*, inlet check-stops, outlet ball valve
4. 2” inlets, 2” outlet
5. 1 GPM (3.8 l/min) minimum flow capacity
6. Maximum operating pressure: 125 PSI (860 KPA)
7. Inlet manifold piping
8. Dura-trol® solid bimetal thermostat directly linked to valve porting to control the intake of hot and cold water and compensate for supply temperature or pressure fluctuations. Dura-trol® is highly responsive and cannot be damaged by extremes in temperature
9. Adjustable high temperature limit stop* set for 120ºF (49ºC)
10. Combination check-stops, strainers on inlets
11. Thermometer on outlet

B. Individual-Fixture, Water Tempering Valves (TMV-2):
1. Standard: ASSE 1017, thermostatically controlled down 0.25 GPM, water tempering valve.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
5. Inlets and Outlet: Threaded.
6. Finish: Rough or chrome-plated bronze.
7. Tempered-Water Setting: 110 deg F.
8. Valve Finish: Rough bronze.

C. Master Water Tempering Valves (TMV-3):
1. Standard: ASSE 1017, thermostatically controlled down 0.25 GPM, water tempering valve.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
5. Inlets and Outlet: Threaded.
6. Finish: Rough or chrome-plated bronze.
7. Tempered-Water Setting: 120 deg F.
8. Valve Finish: Rough bronze.

2.06 STRainers FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
   a. Strainers NPS 2 (DN 50) and Smaller: 0.020 inch (0.51 mm)
   b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch (1.14 mm)
   c. Strainers NPS 5 (DN 125) and Larger: 0.10 inch (2.54 mm) (3.18 mm)

2.07 HOSE BIBBS

A. Hose Bibbs HB-1 (Interior):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Woodford Manufacturing Company.
   b. Zurn Industries, LLC.
   d. Watts; a Watts Water Technologies company.
2. Standard: ASSE Standard 1052
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Service Areas: Rough bronze.
11. Finish for Finished Rooms: Chrome or nickel plated.
12. Operation for Equipment Rooms: Wheel handle or operating key.
15. Include operating key with each operating-key hose bibb.
16. Include integral wall flange with each chrome- or nickel-plated hose bibb.

B. Hose Bibbs HB-2 (Exterior):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Woodford Manufacturing Company.
   d. Zurn Industries, LLC.
4. Operation: Loose key.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
8. Box: Deep, flush mounted with cover.

C. Hose Bibbs HB-3 (Exterior):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Woodford Manufacturing Company.
   c. Watts; a Watts Water Technologies company.
   d. Zurn Industries, LLC.
4. Operation: Loose key.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
8. Box: Deep, flush mounted with cover.

2.08 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
2. Pressure Rating: 400-psig minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

2.09 WATER-HAMMER ARRESTORS

A. Water-Hammer Arrestors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Precision Plumbing Products.
      b. Sioux Chief Manufacturing Company, Inc.
      c. Watts; a Watts Water Technologies company.
      d. Zurn Industries, LLC.
   3. Type: Copper tube with piston.
   4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.10 AIR VENTS

A. Welded-Construction Automatic Air Vents:
   2. Pressure Rating: 150-psig minimum pressure rating.
   3. Float: Replaceable, corrosion-resistant metal.

2.11 TRAP-SEAL PRIMER DEVICES

A. Supply-Type, Trap-Seal Primer Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. MIFAB, Inc.
      b. Precision Plumbing Products.
      c. Zurn Industries, LLC.
   5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
   6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
   7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Trap-Seal Primer Systems:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Precision Plumbing Products.
      b. Zurn Industries, LLC.
   2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B88, Type L (DN 20, ASTM B88M, Type B); copper, wa-
ter tubing.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac
   power.
   a. Electrical Components, Devices, and Accessories: Listed and labeled as
defined in NFPA 70, by a qualified testing agency, and marked for intended
   location and application.
7. Size Outlets: NPS 1/2 (DN 15).

2.12 FLEXIBLE CONNECTORS

A. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with
   stainless-steel wire-braid covering and ends welded to inner tubing.
   2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.13 AQUASTAT CONTROLLER

A. Electronic Stand- Alone Controller:
   1. Manufacturers: Subject to compliance with requirements, provide products by
      one of the following:
      a. Honeywell Inc.
      b. White-Rodgers Inc.
      c. Or approved equal.
   2. Two independent modulating outputs.
   3. Internal time clock scheduler.
   4. Modulating high and low limit control.
   5. NEMA 4X enclosure

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install water regulators with inlet and outlet shutoff valves and bypass with memory-
   stop balancing valve. Install pressure gauges on inlet and outlet.

B. Install water-control valves with inlet and outlet shutoff valves and bypass with globe
   valve. Install pressure gauges on inlet and outlet.

C. Install balancing valves in locations where they can easily be adjusted.

D. Install temperature-actuated, water mixing valves with check stops or shutoff valves on
   inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Install Y-pattern strainers for water on supply side of each control valve, water pres-
   sure-reducing valve and pump.
F. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Division 06.

G. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Division 06.

H. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

I. Install water-hammer arrestors in water piping according to PDI-WH 201.

J. Install air vents at high points of water piping. Install drain piping and discharge onto floor sink.

K. Install trap-seal primer devices with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

L. Charge domestic-water expansion tanks with air.

3.02 CONNECTIONS

A. Comply with requirements for ground equipment in Division 26.

B. Fire-retardant-treated-wood blocking is specified in Division 26.

3.03 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Calibrated balancing valves.
   2. Primary, thermostatic, water mixing valves.
   3. Primary water tempering valves.
   5. Hose bibbs.
   6. Trap-seal primer devices.
   7. Aquastat.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Test each backflow preventer according to authorities having jurisdiction and the device’s reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.05 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION
SECTION 22 11 23
DOMESTIC WATER PUMPS.

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section Includes:
      1. Circulating pump
   B. Related Sections:
      1. Section 22 00 00 “Plumbing General Requirements”

1.03 DEFINITIONS
   A. VFC: Variable-frequency controller(s).

1.04 PERFORMANCE REQUIREMENTS
   A. Seismic Performance: Circulation pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
      1. The term “withstand” means “the circulation pump will remain in place without separation of any parts from the circulation pump when subjected to the seismic forces specified and the circulation pump will be fully operational after the seismic event.”

1.05 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   B. Shop Drawings: For circulation pumps. Include plans, elevations, sections, details, and attachments to other work.
      1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
      2. Wiring Diagrams: For power, signal, and control wiring.
   C. Sustainable Design Submittals:
      1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
      2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
         a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.06 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For circulation pumps, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For circulation pumps to include in emergency, operation, and maintenance manuals.

1.08 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Comply with ASME B31.9 for piping.

C. UL Compliance for Packaged Pumping Systems:
   1. UL 508, “Industrial Control Equipment.”
   2. UL 508A, “Industrial Control Panels.”
   3. UL 778, “Motor-Operated Water Pumps.”

D. Circulation pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Retain protective coatings and flange’s protective covers during storage.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.
2.02 CIRCULATING PUMPS CP-1, CP-2 AND CP-3

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bell & Gossett; a Xylem brand.
   b. Grundfos Pumps Corporation U.S.A.
   c. Or approved equal.

2. Inline permanently lubricated pump shall be lead-free bronze body construction, suitable for use in a domestic water system.

3. Furnish centrifugal close coupled single stage circulating pumps with capacities as scheduled in the Pump Schedule on the Drawings.

4. Circulating pumps shall be of the in-line type suitable for vertical installation and be serviceable without dismantling the circulator piping connections.

5. Casings shall be brass, ASTM B584.

6. Maximum pump working pressure shall be 150 psi.

7. Maximum operation temperature 225 °F.

8. Impeller shall be bronze, closed type, ASTM B584, 304 stainless steel impeller key, keyed to the shaft, brass impeller washer, 304 stainless steel impeller lock washer and a impeller cap screw.

9. The pumps shall have a steel shaft supported be permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide.

10. The motor shall be non-overloading at any point on the pump performance curve.

11. The motor shall be of the drip-proof, sealed precision ball-bearing, quiet-operating construction. The permanent split-capacitor motor shall be equipped with thermal overload protection.

12. Pump motor shall be as specified on the Drawings for horsepower, voltage and phase, and in Section 22-05-13 – Common Motors for Plumbing. Motor shall be non-overloading throughout the entire range of the pump curve.

13. Pump manufacturer shall be ISO-9001 certified.

B. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for circulation pumps to verify actual locations of piping connections before circulation-pump installation.

3.02 INSTALLATION

A. Equipment Mounting:
1. Comply with requirements for vibration isolation and seismic control devices as specified.
2. Comply with requirements for vibration isolation devices as specified.

B. Support connected domestic-water piping so weight of piping is not supported by circulation pumps.

3.03 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 11 16 “Domestic Water Piping.” Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect domestic-water piping to circulation pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.
   1. Install shutoff valves on piping connections to circulation pump suction and discharge headers. Install ball, valves same size as suction and discharge headers.
   2. Install union, flanged, or grooved-joint connections on suction and discharge headers at connection to domestic-water piping.
   3. Install piping adjacent to circulation pumps to allow service and maintenance.

3.04 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

3.05 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Perform visual and mechanical inspection.
   2. Leak Test: After installation, charge circulation pump and test for leaks. Repair leaks and retest until no leaks exist.
   3. Operational Test: After electrical circuitry has been energized, start circulation pumps to confirm proper motor rotation and circulation-pump operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.
3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer’s written instructions.

3.07 ADJUSTING

A. Adjust circulation pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust reverse circulation pumps to function smoothly and lubricate as recommended by manufacturer.

C. Adjust pressure set points.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting circulation pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain circulation pumps.

END OF SECTION
SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground piping.

B. Related Requirements:
   1. Division 01 for sustainability requirements.
   2. Section 22 13 19 – Sanitary Waste Piping Specialties
   3. Section 22 00 00 – Plumbing General Requirements
   4. Division 31 for earth moving.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. Shop Drawings: For hub-less drainage system. Include plans, elevations, sections, and details.

1.04 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.
1.05 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Construction Manager no fewer than two days in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Construction Manager’s written permission.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.02 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.03 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in “Piping Schedule” Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

C. Pipe, fittings and couplings shall be manufactured in the United States.

D. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute or receive prior approval of the engineer.

E. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AB&I Foundry
   2. Charlotte Pipe
   3. Tyler Pipe

2.04 UNDERGROUND SANITARY VENT, SANITARY SEWER – HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTING.

A. All underground sanitary, storm and vent piping systems under building and within 5 feet 0 inches of the building’s exterior foundation, unless otherwise noted on the Drawings.
B. Hub and Spigot Type Pipe and Fittings: Service weight cast iron soil pipe with weight per foot and maker’s name clearly stamped or cast on each length, in conformance with ASTM A74 and CISPI HSN, and push-on rubber gasketed joint to affect a watertight seal, in conformance with ASTM C564.

C. No Hub Type Pipe and Fittings: No hubcast iron soil pipe and fittings shall be labeled with the CI mark of quality and permanence as illustrated in latest standards of Cast Iron Soil Pipe Institute (CISPI) Standard 301, ASTM A888 or ASTM A74, and no hub drainage pattern fittings.

1. Heavy-Duty, Hubless-Piping Couplings: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Mission Rubber Company, LLC.
   c. Tyler Pipe.


D. Description: Stainless-steel shield with four stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

E. Gaskets: ASTM C564, rubber.

2.05 ABOVE GRADE – SANITARY VENT, SANITARY SEWER:

A. No hub, service weight, cast iron soil pipe labeled with the CI mark of quality and permanence as illustrated in latest standards of Cast Iron Soil Pipe Institute (CISPI) Standard 301, ASTM A888 or ASTM A74, and no hub drainage pattern fittings.

B. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Mission Rubber Company, LLC.
   c. Tyler Pipe.


3. Description: Stainless-steel shield with four stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stops.

C. Couplings:

1. Underground and Above Grade Heavy Duty No Hub Couplings:
   a. No-hub couplings shall comply with CISPI 310 and all requirements of Factory Mutual 1680 Class I, 15 psi rated pressure. No-Hub couplings shall be constructed of Type 304 stainless steel with 305 stainless steel worm drive screws. The worm drive clamps shall have a hexagon head to accept a 3/8 inch socketed torque wrench. The clamps shall be tightened to a minimum of 80 inch pounds. (Single corrugated shield, 4 band 80 inch pound torque or 2 band 125 inch pound torque minimum). The gasket material shall be neoprene rubber meeting the requirements of ASTM C564. Submittal to include copy of compliance to the requirements of FM 1680 Class I by certified independent third-party testing laboratory. No-Hub couplings shall be Husky SD4000 or Clamp-All High Torq 125.
2.06 INDIRECT WASTE PIPING:

A. Unfinished Spaces: Type DWV copper tube with solder-fitting drainage type, cast copper couplings. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

B. Finished Spaces: Chrome plated brass piping with chrome plated brass threaded drainage pattern fittings.

C. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

2.07 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND METAL PIPING AND COUPLINGS

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material:
   1. Linear low-density polyethylene film of 0.008-inch minimum thickness.
   2. Direct buried ductile iron pipe should be encased in 8-mil polyethylene as specified in AWWA specification C-105. Epoxy coatings are also an acceptable alternative type of coating system for the pipe and/or fittings such as valves.
   3. All rubber gasket joints, fusion-bonded epoxy coated flanges and flexible couplings on ductile iron pipelines should be bonded with insulated copper cable to insure electrical continuity of the pipeline and fittings.
   4. Insulating flanges and/or couplings should be installed to electrically isolate the buried portion of pipeline from other metallic pipelines, reinforced concrete structures and above grade buildings or structures.
   5. Test stations shall be installed on all ductile iron pipelines at a spacing of 800 to 1,000 feet. Bonding and test stations shall comply with NACE Standards.
   6. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the entire length of buried metallic pipeline. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.08 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
   1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
   2. Shielded, Nonpressure Transition Couplings:
      b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
      c. End Connections: Same size as and compatible with pipes to be joined.

B. Pressure Transition Couplings:
2. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
4. Gasket Material: Natural or synthetic rubber.
5. Metal Component Finish: Corrosion-resistant coating or material.

C. Dielectric Fittings:
1. Dielectric Flanges:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Wilkins.
   d. Zurn Industries, LLC.
2. Description:
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 125 psig minimum at 180 deg F.
   d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric Nipples:
1. 6" brass nipple.

2.09 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND DUCTILE IRON FITTINGS:

A. All direct buried ductile iron fittings installed on non-metallic piping shall be provided with a bituminous coating from the factory and encased in an 8-mil polyethylene bag in the field in accordance with AWWA Specification C-105. All bolts, restraining rods, etc. shall be coated with bitumastic prior to encasement in the polyethylene bag.

B. All metallic valves shall be coated from the factory (i.e. using powdered epoxy or equivalent type of coating system) and all bolts shall be coated with bitumastic in the field and the entire valve shall be encased in an 8-mil polyethylene bag in accordance with AWWA Specification C-105.

C. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the valves and fittings. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31.
3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
   1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
   2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas as at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 “Vibration and Seismic Controls for Plumbing Piping and Equipment.”

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
   2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
      a. Straight tees, elbows, and crosses may be used on vent lines.
   3. Do not change direction of flow more than 90 degrees.
   4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
   5. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building storm drainage piping beginning at low point of each system.
   1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
   2. Install required gaskets according to manufacturer’s written instructions for use of lubricants, cements, and other installation requirements.
   3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the minimum slopes indicated on drawings.
1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

   1. [Install protection on underground piping according to ASTM A674 or AWWA C105/A21.5.]

N. Install steel piping according to applicable plumbing code.

O. Install aboveground copper tubing according to CDA’s “Copper Tube Handbook.”

P. Install force mains at elevations indicated.

Q. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
      a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
      b. Comply with requirements for cleanouts specified in Section 22 13 19 “Sanitary Waste Piping Specialties.”
   2. Install drains in sanitary waste gravity-flow piping.

R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

S. Install sleeves for piping penetrations of walls, ceilings, and floors.
   1. Comply with requirements for sleeves specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

T. Install sleeve seals for piping penetrations of concrete walls and slabs.
   1. Comply with requirements for sleeve seals specified in Section 22 05 17 “Sleeves and Sleeve Seals for Plumbing Piping.”

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.
   1. Comply with requirements for escutcheons specified in Section 22 05 18 “Escutcheons for Plumbing Piping.”

3.03 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI’s “Cast Iron Soil Pipe and Fittings Handbook” for compression joints.

B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI’s “Cast Iron Soil Pipe and Fittings Handbook” for hubless-piping coupling joints.
C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.
   1. Cut threads full and clean using sharp dies.
   2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
      a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
      b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
      c. Do not use pipe sections that have cracked or open welds.

D. Join stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.

E. Join copper tube and fittings with soldered joints according to ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

H. Comply with requirements in Section 22 05 23 “General Duty Valves for Plumbing Piping”.

I. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices as specified.

B. Comply with requirements for pipe hanger and support devices and installation per CPC
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. [Install stainless steel or fiberglass pipe hangers for horizontal piping in corrosive environments.]
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. [Install stainless-steel pipe support clamps for vertical piping in corrosive environments.]
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Install individual, straight, horizontal piping runs:
      a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. **Base of Vertical Piping**: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
   4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
   5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
   6. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   7. NPS 6 and NPS 8 (DN 150 and DN 200): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
   4. NPS 3 and NPS 5 (DN 80 and DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
   5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
   6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

K. Install supports for vertical copper tubing every 10 feet (3 m).
3.05 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:
   1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. Comply with requirements for cleanouts and drains specified in Section 22 13 19 “Sanitary Waste Piping Specialties.”
   6. Equipment: Connect waste piping as indicated.
      a. Provide shutoff valve if indicated and union for each connection.
      b. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main.
   2. Sewage Pump: To sewage pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.06 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

3.07 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
      a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
      a. Close openings in piping system and fill with water to point of overflow, but not less than 30 kPa (10-foot head of water).
      b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
      c. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
      a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa).
      b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
      c. Air pressure must remain constant without introducing additional air throughout period of inspection.
      d. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.
      a. Isolate test source and allow to stand for four hours.
      b. Leaks and loss in test pressure constitute defects that must be repaired.
HMC Architects

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.08 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.
B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
C. Place plugs in ends of uncompleted piping at end of day and when work stops.
D. Repair damage to adjacent materials caused by waste and vent piping installation.

END OF SECTION
SECTION 22 13 19
SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

   A. Section Includes
      1. Cleanouts.
      2. Roof flashing assemblies.
      3. Through-penetration firestop assemblies.

   B. Related Requirements:
      1. Section 22 13 16 “Sanitary Waste and Vent Piping.”
      2. Section 22 14 23 “Storm Drainage Piping Specialties” for trench drains for storm water, channel drainage systems for storm water, roof drains.
      3. Division 33 for storm drainage piping and piping specialties outside the building.

1.03 DEFINITIONS


1.04 ACTION SUBMITTALS

   A. Product Data: For each type of product. Include rated capacities, operating characteristics, and accessories.

   B. Sustainable Design Submittals:
      1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
      2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
         a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
         b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.05 INFORMATIONAL SUBMITTALS

   A. Seismic Qualification Certificates: accessories and components, from manufacturer.
      1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 18120.

2.02 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.03 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Zurn Industries, LLC.
      c. Josam Company.
      d. Or approved equal.
   2. Standard: ASME A112.36.2M.
   3. Size: Same as connected drainage piping
   4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
   5. Closure: Countersunk or raised-head, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   7. Refer to Schedules.

B. Cast-Iron Exposed Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Josam Company.
      c. Zurn Industries, LLC.
d. Or approved equal.
2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule, heavy-duty, adjustable housing threaded.
5. Body or Ferrule: Cast iron.
6. Clamping Device: As required.
7. Outlet Connection: Inside calk, spigot or Threaded.
8. Closure: Brass plug with tapered threads.
9. Adjustable Housing Material: Cast iron with threads.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A74, service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Josam Company.
   c. Zurn Industries, LLC.
   d. Or approved equal.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hub-and-spigot, cast-iron soil pipe T-branch or hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure Plug:
   a. Brass.
   b. Countersunk or raised head.
   c. Drilled and threaded for cover attachment screw.
   d. Size: Same as or not more than one size smaller than cleanout size.

2.04 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Thaler Metal Industries Ltd.
   c. Zurn Industries, LLC.
   d. Or approved equal.
2. Description: Manufactured assembly made of 4.0-lb/sq. ft. 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
   b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
   c. Extended Vent Cap: With field-installed, vandal-proof vent cap.
2.05 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by
      one of the following:
      a. 3M.
      b. Hilti.
      c. ProSet Systems Inc.
      d. Or approved equal.
   3. Size: Same as connected soil, waste, or vent stack.
   4. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral
      nailing flange on one end for installation in cast-in-place concrete slabs.

2.06 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:
   1. Description: Shop or field fabricate from ASTM A74, Service class, hub-and-
      spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section;
      and where required, increaser fitting joined with ASTM C564 rubber gaskets.
   2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:
   1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected
      piping and cleanout trap-seal primer valve connection.
   2. Size: Same as connected waste piping.
      a. NPS 24-inch-minimum water seal.
      b. NPS 2-1/2and Larger: 5-inch-minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:
   1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-
      seal primer valve connection.
   2. Size: Same as floor drain outlet with NPS 1/2side inlet.

D. Air-Gap Fittings:
   1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap
      between installed inlet and outlet piping.
   2. Body: Bronze or cast iron.
   3. Inlet: Opening in top of body.
   4. Outlet: Larger than inlet.
   5. Size: Same as connected waste piping and with inlet large enough for associated
      indirect waste piping.

E. Sleeve Flashing Device:
   1. Description: Manufactured, cast-iron fitting, with clamping device that forms
      sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel
      pipe extension in top of fitting that will extend 2 inches unless otherwise noted
      above finished floor and galvanized-steel pipe extension in bottom of fitting that
      will extend through floor slab.
   2. Size: As required for close fit to riser or stack piping.
F. Stack Flashing Fittings:
   1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
   2. Size: Same as connected stack vent or vent stack.

G. Vent Caps:
   1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
   2. Size: Same as connected stack vent or vent stack.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:
   1. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 22 05 48 “Vibration and Seismic Controls for Plumbing Piping and Equipment.”

B. Install backwater valves in building drain piping where required.
   1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Division 07.

G. Assemble open drain fittings and install with top of hub 2 inches above floor unless otherwise noted.

H. Install deep-seal traps on floor drains and other waste outlets, if indicated.

I. Install floor-drain, trap-seal primer fittings on inlet of all floor drains, floorsinks, and hub drains.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.
J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

L. Install vent caps on each vent pipe passing through roof.

M. Install reinforcement for wall-mounting-type specialties.

N. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.02 CONNECTIONS

A. Comply with requirements in Section 22 13 16 “Sanitary Waste and Vent Piping” for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.03 FLASHING INSTALLATION

A. Comply with requirements in Division 07.

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
   2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
   3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings.

3.04 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
   1. Nameplates and signs are specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”
3.05 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.06 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section includes:
      1. Floor drains.
      2. Floor sinks.
      4. Outlet wall box.
      5. Drain trough.
      6. Roof receptor.

1.03 ACTION SUBMITTALS
   A. Product Data: For each type of product.
   B. Sustainable Design Submittals:
      1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
      2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
         a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
         b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE
   A. All products must comply with LEED + WELL material performance requirements per section 18120

2.02 DRAIN ASSEMBLIES
   A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.
   B. Refer to the Drawings for the basis of design products, characteristics, and required options.
2.03 FLOOR DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.

B. Body Material:
   1. Gray cast-iron. Floor drains shall be in accordance with ASME A112.6.3.
   2. Stainless steel. Floor drains shall be in accordance with ASME A112.3.1.

C. Provide with no-hub, threaded, or inside gasket connection. Floor drains shall have internal seepage collar for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Provide clamping device where required or where indicated on drawings. Include trap primer connection where indicated on drawings.

2.04 FLOOR SINKS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.
   4. Or approved equal.

B. Body Material:
   1. Gray cast-iron. Floor sinks shall be in accordance with ASME A112.6.3.
   2. Stainless steel. Floor sinks shall be in accordance with ASME A112.3.1.

C. Provide with no-hub, threaded, or inside gasket connection. Double drainage pattern floor sink shall have anchoring and seepage flanged for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Provide clamping device where required or where indicated on drawings. Include trap primer connection where indicated on drawings.

2.05 SHOWER DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.
   4. Or approved equal.

B. Body Material:
   1. Gray cast-iron. Floor sinks shall be in accordance with ASME A112.6.3.
   2. Stainless steel. Floor sinks shall be in accordance with ASME A112.3.1.

C. Provide with no-hub, threaded, or inside gasket connection. Double drainage pattern shower drain shall have anchoring and seepage flanged for embedding in floor con-
struction and weep holes to provide adequate drainage to drain pipe. Provide clamping device where required or where indicated on drawings.

2.06 OUTLET BOX

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Guy Gray, LLC. IPS Corporation
   2. Sioux Chief.
   3. Or approved equal.

B. Materials:
   1. Drain outlet located on the center
   2. Body:
      a. Constructed from hot dipped galvanized steel 20 gauge box and 20 gauge faceplate;

2.07 DRAIN TROUGH

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. H-M Company
   2. Or approved equal.

B. Materials:
   1. Body:
      a. ¼" Polypropylene.
   2. Lid Materials
      a. 3/8" Polypropylene.
   3. Lint Filter:
      a. ¼" PVC.

C. Provide with no-hub, threaded, or inside gasket connection. Double drainage pattern drain trough shall have anchoring and seepage flanged for embedding in floor construction and weep holes to provide adequate drainage to drain pipe. Provide clamping device where required or where indicated on drawings. Include trap primer connection where indicated on drawings.

2.08 ROOF RECEPTOR

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Zurn Industries, LLC.
   4. Or approved equal.

B. Body Material:
   1. Gray cast-iron. Roof receptor shall be in accordance with ASME A112.6.3.
C. Provide with no-hub, threaded, or inside gasket connection. Provide clamping device where required or where indicated on drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
   3. Set with grates depressed according to the following drainage area radii:
      a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
      b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
      c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
   4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
      a. Maintain integrity of waterproof membranes where penetrated.
   5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.02 CONNECTIONS

A. Comply with requirements in Section 22 13 16 “Sanitary Waste and Vent Piping” for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 22 13 19 “Sanitary Waste Piping Specialties” for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Division 26.

E. Connect wiring according to Division 26.

3.03 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

3.04 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
SECTION 22 14 13
STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.

B. Related Sections:
   1. Section 01 81 13 “Sustainability and LEED – V4 Requirements” for sustainability requirements.
   2. Division 31 for earth moving.
   3. Division 33 for storm drainage piping outside the building.

1.03 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water (30 kPa).

B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.05 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Field Conditions:
1. Pipe shall be transported to the site in enclosed vehicles or with ends covered.
2. Do not store pipe directly on ground or floor.
3. Pipe stored or stacked on site shall be covered.

1.07 PROJECT CONDITIONS

A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
1. Notify Construction Manager no fewer than two days in advance of proposed interruption of storm-drainage service.
2. Do not proceed with interruption of storm-drainage service without Construction Manager’s written permission.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 PIPING MATERIALS

A. Comply with requirements in “Piping Schedule” Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All materials specified in this section shall be manufactured in the United States.

C. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute or receive prior approval of the engineer.

D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AB&I Foundry.
2. Charlotte Pipe.
3. Tyler Pipe.
2.03 UNDERGROUND STORM SYSTEM: HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A74, Service classes.

B. Gaskets: ASTM C564, rubber.

C. Service weight cast iron soil pipe with weight per foot and maker’s name clearly stamped or cast on each length, in conformance with ASTM A74 and CISPI HSN, and push-on rubber gasketed joint to affect a water-tight seal, in conformance with ASTM C564.

D. No Hub Type Pipe and Fittings: No hubcast iron soil pipe and fittings shall be labeled with the CI mark of quality and permanence as illustrated in latest standards of Cast Iron Soil Pipe Institute (CISPI) Standard 301, ASTM A888 or ASTM A74, and no hub drainage pattern fittings.

E. Heavy-Duty, Hubless-Piping Couplings: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ANACO-Husky.
   2. Mission Rubber Company, LLC.
   3. Tyler Pipe.

F. Couplings:
   1. Underground Heavy Duty No Hub Couplings:
      a. No-hub couplings shall comply with CISPI 310 and all requirements of Factory Mutual 1680 Class I, 15 psi rated pressure. No-Hub couplings shall be constructed of Type 304 stainless steel with 305 stainless steel worm drive screws. The worm drive clamps shall have a hexagon head to accept a 3/8 inch socketed torque wrench. The clamps shall be tightened to a minimum of 80 inch pounds. (Single corrugated shield, 4 band 80 inch pound torque or 2 band 125 inch pound torque minimum). The gasket material shall be neoprene rubber meeting the requirements of ASTM C564. Submittal to include copy of compliance to the requirements of FM 1680 Class I by certified independent third-party testing laboratory. No-Hub couplings shall be Husky SD4000 or Clamp-All High Torq 125

2.04 ABOVE GRADE STORM SYSTEM: HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ANACO-Husky.
      b. Mission Rubber Company, LLC.
      c. Tyler Pipe.
3. Description: Stainless-steel shield with four stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

C. Couplings:
1. Heavy Duty No Hub Couplings:
   a. No-hub couplings shall comply with CISPI 310 and all requirements of Factory Mutual 1680 Class I, 15 psi rated pressure. No-Hub couplings shall be constructed of Type 304 stainless steel with 305 stainless steel worm drive screws. The worm drive clamps shall have a hexagon head to accept a 3/8 inch socketed torque wrench. The clamps shall be tightened to a minimum of 80 inch pounds. (Single corrugated shield, 4 band 80 inch pound torque or 2 band 125 inch pound torque minimum). The gasket material shall be neoprene rubber meeting the requirements of ASTM C564. Submittal to include copy of compliance to the requirements of FM 1680 Class I by certified independent third-party testing laboratory. No-Hub couplings shall be Husky SD4000 or Clamp-All High Torq 125.

2.05 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:
1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
3. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Ductile-Iron, Grooved-Joint Piping:
2. Ductile-Iron-Pipe Appurtenances:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Anvil International.
      2) Victaulic Company.
   c. Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.

2.06 GALVANIZED STEEL PIPE AND FITTINGS
1. Standard weight galvanized steel pipe, schedule 40
   a. Fittings: Galvanized malleable iron with flat band, steam pattern (vent piping) and cast iron drainage pattern (waste piping).
   b. Joints: Teflon tape applied to male threads only, with no tape or loose ends extending into pipe or past the first thread of the male end. Approved grooved couplings and fittings may be used.
2.07 SOIL CORROSIVITY PROTECTION FOR UNDERGROUND METAL PIPING AND COUPLINGS

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material:
1. Linear low-density polyethylene film of 0.008-inch minimum thickness.
2. Direct buried ductile iron pipe should be encased in 8-mil polyethylene as specified in AWWA specification C-105. Epoxy coatings are also an acceptable alternative type of coating system for the pipe and/or fittings such as valves.
3. All rubber gasket joints, fusion-bonded epoxy coated flanges and flexible couplings on ductile iron pipelines should be bonded with insulated copper cable to insure electrical continuity of the pipeline and fittings.
4. Insulating flanges and/or couplings should be installed to electrically isolate the buried portion of pipeline from other metallic pipelines, reinforced concrete structures and above grade buildings or structures.
5. Test stations shall be installed on all ductile iron pipelines at a spacing of 800 to 1,000 feet. Bonding and test stations shall comply with NACE Standards.
6. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the entire length of buried metallic pipeline. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

2.08 SPECIALTY PIPE FITTINGS

A. Transition Couplings:
1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Shielded, Nonpressure Transition Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1) Mission Rubber Company, LLC; a division of MCP Industries.
   c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   d. End Connections: Same size as and compatible with pipes to be joined.
4. Pressure Transition Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Dresser, Inc.
      3) Romac Industries, Inc.
      4) Or approved equal.
   c. Description: Metal, sleeve-type couplings same size as, with pressure rating at least equal to and ends compatible with, pipes to be joined.
d. Center-Sleeve Material: Stainless steel.
e. Gasket Material: Natural or synthetic rubber.
f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:
1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Flanges:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Watts; a Watts Water Technologies company.
      2) Wilkins.
      3) Zurn Industries, LLC.
      4) Or approved equal.
   c. Factory-fabricated, bolted, companion-flange assembly.
      1) Pressure Rating: 150 psig (1035 kPa).
      2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
3. Dielectric Nipples: 6” red brass nipple.

2.09 SOIL CORROSIONITY PROTECTION FOR UNDERGROUND DUCTILE IRON FITTING

A. All direct buried ductile iron fittings installed on non-metallic piping shall be provided with a bituminous coating from the factory and encased in an 8-mil polyethylene bag in the field in accordance with AWWA Specification C-105. All bolts, restraining rods, etc. shall be coated with bitumastic prior to encasement in the polyethylene bag.

B. All metallic valves shall be coated from the factory (i.e. using powdered epoxy or equivalent type of coating system) and all bolts shall be coated with bitumastic in the field and the entire valve shall be encased in an 8-mil polyethylene bag in accordance with AWWA Specification C-105.

C. A sacrificial type of cathodic protection utilizing magnesium anodes should be installed to protect the valves and fittings. Cathodic protection should be designed in accordance with NACE Standard SP0169-13 and applicable local standards and included with the contract documents to permit installation along with the pipeline.

PART 3 - EXECUTION

3.01 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31.

3.02 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and
calculate friction loss, expansion and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint per CPC.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. Do not change direction of flow more than 90 degrees.
   2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
   3. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install storm drainage piping at the minimum slopes indicated on drawings.


N. Install encasement on underground piping according to ASTM A674 or AWWA C105.

O. Install steel piping according to applicable plumbing code.

P. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to storm sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
   1. Install encasement on piping according to ASTM A674 or AWWA C105.
Q. Install force mains at elevations indicated.

R. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 22 14 23 “Storm Drainage Piping Specialties.”
   2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 14 23 “Storm Drainage Piping Specialties.”

S. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves.

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified.

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons.

3.03 JOINT CONSTRUCTION


C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Join copper tube and fittings with soldered joints according to ASTM B828 procedure. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

E. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fittings. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

F. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
3.04 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in ODs.
   2. In Drainage Piping: Shielded, nonpressure transition couplings.
   4. In Underground Force-Main Piping:
      a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
      b. NPS 2 (DN 50) and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 4 and Smaller: Use dielectric nipples.

3.05 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified

B. Comply with requirements for pipe hanger and support devices and installation specified
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.

I. Install supports for vertical steel piping every 15 feet.

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
   4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
   5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
   6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

K. Install supports for vertical copper tubing every 10 feet.

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.06 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.
   1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
   2. Comply with requirements for cleanouts and drains specified in Section 22 14 23 “Storm Drainage Piping Specialties.”
D. Connect force-main piping to the following:
   1. Storm Sewer: To exterior force main.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.07 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified.

3.08 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and uncoaled new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than (10-foot) head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

4. Prepare reports for tests and required corrective action.

3.09 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 8 and smaller shall be any of the following:
   1. No hub, service weight, cast iron soil pipe labeled with the CI mark of quality and permanence as illustrated in latest standards of Cast Iron Soil Pipe Institute (CISPI) Standard 301, ASTM A888 or ASTM A74, and no hub drainage pattern fittings.
   2. Dissimilar Pipe-Material Couplings:
      a. Underground and Above Grade Heavy Duty No Hub Couplings: No-hub couplings shall comply with CISPI 310 and all requirements of Factory Mutual 1680 Class I, 15 psi rated pressure. No-Hub couplings shall be constructed of Type 304 stainless steel with 305 stainless steel worm drive screws. The worm drive clamps shall have a hexagon head to accept a 3/8 inch socketed torque wrench. The clamps shall be tightened to a minimum of 80 inch pounds. (Single corrugated shield, 4 band 80 inch pound torque or 2 band 125 inch pound torque minimum). The gasket material shall be neoprene rubber meeting the requirements of ASTM C564. Submittal to include copy of compliance to the requirements of FM 1680 Class I by certified independent third-party testing laboratory. No-Hub couplings shall be Husky SD4000 or Clamp-All High Torq 125.

C. Underground storm drainage piping shall be any of the following:
   1. Hub and Spigot Type Pipe and Fittings: Service weight cast iron soil pipe with weight per foot and maker’s name clearly stamped or cast on each length, in conformance with ASTM A74 and CISPI HSN, and push-on rubber gasketed joint to affect a water-tight seal, in conformance with ASTM C564.
   2. No Hub Type Pipe and Fittings: No hubcast iron soil pipe and fittings shall be labeled with the CI mark of quality and permanence as illustrated in latest stand-
ards of Cast Iron Soil Pipe Institute (CISPI) Standard 301, ASTM A888 or ASTM A74, and no hub drainage pattern fittings. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

a. Heavy-Duty, Hubless-Piping Couplings: Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. ANACO-Husky.
   c. Mission Rubber Company, LLC.
   d. Tyler Pipe.
   e. Standards: ASTM C1277 and ASTM C1540.


D. Gutter storm drainage exposed piping (Building B) shall be any of the following:
1. Standard Weight Galvanized Steel Pipe, Schedule 40:
2. Fittings: Galvanized malleable iron with flat band, steam pattern (vent piping) and cast iron drainage pattern (waste piping).
3. Joints: Teflon tape applied to male threads only, with no tape or loose ends extending into pipe or past the first thread of the male end. Approved grooved couplings and fittings may be used.

END OF SECTION
SECTION 22 14 23
STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Roof drains and Overflow drains.
   2. Canopy drains and Overflow drains.
   3. Planer drains.
   4. Miscellaneous storm drainage piping specialties.
   5. Cleanouts.
   7. Flashing materials.

B. Related Requirements:
   1. Section 22 14 13 “Storm Drainage Piping.”

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 ROOF DRAINS AND OVERFLOW DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Zurn Industries, LLC.
      c. Watts; a Watts Water Technologies company.
      d. Or approved equal.

B. Standard: ASME A112.6.4, for general-purpose roof drains.
   2. Dimension of Body: Nominal 14-inch diameter.
   3. Combination Flashing Ring and Gravel Stop: Required.
   5. Outlet: Bottom.
   7. Underdeck Clamp: Required.
   8. Expansion Joint: Not required.
  10. Dome Material: Cast iron.
  11. Perforated Gravel Guard: Not required.

C. Water Dam: 2 inches high. Water dam required on overflow drains only.

2.03 CANOPY DRAINS AND OVERFLOW DRAINS.

A. Cast-Iron, Cornice Canopy Roof Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Zurn Industries, LLC.
      c. Watts; a Watts Water Technologies company.
      d. Or approved equal.

B. 4-1/2" diameter by 2" high cornice drain, dura-coated cast iron body, polished nickel bronze dome, and membrane flashing clamp.

2.04 PLANTER AREA DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Zurn Industries, LLC.

B. Body Material:
1. Duco-cast iron lower body and flashing collar with 4(100) PVC perforated stand-pipe and duco-cast iron upper body with combined flashing clamp and gravel stop with polyethylene dome.
2. Provide with no-hub, threaded, or inside gasket connection.

2.05 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Cover:
1. Description: Manufactured, ASTM A48/A48M, gray-iron casting, with strap or ears for attaching to building and shop-applied bituminous coating.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Zurn Industries, LLC.
   c. Or approved equal.
3. Description: Round fabricated stainless steel frame with fabricated secured perforated steel hinged strainer.

2.06 CLEANOUTS

A. Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Watts; a Watts Water Technologies company.
   c. Zurn Industries, LLC.
   d. Or approved equal.
2. Refer to Schedules for Basis of Design.
3. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
4. Size: Same as connected branch.
5. Type: Adjustable housing.
6. Body or Ferrule Material: Cast iron.
7. Clamping Device: Required.
10. Adjustable Housing Material: Cast iron with threads.
12. Frame and Cover Shape: Round.
14. Riser: ASTM A74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Watts; a Watts Water Technologies company.
c. Zurn Industries, LLC.
d. Or approved equal.

2. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. Watts; a Watts Water Technologies company.
      c. Zurn Industries, LLC.
      d. Or approved equal.
   2. Refer to Schedules for Basis of Design.
   3. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
   4. Size: Same as connected drainage piping.
   5. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
   6. Closure: Countersunk, plug.
   7. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   8. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer’s written installation instructions.
   1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Install expansion joints, if indicated, in roof drain outlets.
   3. Position roof drains for easy access and maintenance.

B. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

C. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
   1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
   3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate cleanouts at base of each vertical soil and waste stack.
D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install test tees in vertical conductors and near floor.

G. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

H. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

I. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

J. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.02 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 14 13 “Storm Drainage Piping.” Drawings indicate general arrangement of piping, fittings, and specialties.

3.03 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION
SECTION 22 33 00

ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Electric Domestic Water Heaters EWH-A (Building A), EWH-B (Building B) and EWH-C (Building C);
3. Air Source Heat Pump Water Heaters HP-C-1 and HP-C-2 (Building C)
4. Commercial storage tank ST-1 (Building A) and ST-2 (Building C).
5. Domestic-water heater accessories.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.”

1.04 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
   1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
   2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
      a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
      b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.

C. Shop Drawings:
   1. Wiring Diagrams: For power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial air source heat pumps from manufacturer.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.07 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater and storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, “Drinking Water System Components – Health Effects.”

1.08 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.09 WARRANTY

A. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including storage tank and supports.
   b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.
   a. Commercial, Electric, Storage, Domestic-Water Heaters:
      1) Storage Tank: Five years.
      2) Controls and Other Components: One year.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 COMMERCIAL ELECTRIC DOMESTIC WATER HEATERS

A. Commercial, Electric, Air Source Heat Pumps - HP-A-1, HP-A-2, HP-A-3 (Building A); HP-C-1 and HP-C-2 (Building C)
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      b. See Schedule for Basis for Design
   2. Description: Packaged air-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
      a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   3. Cabinet and Chassis: Factory powder coated appropriate for coastal salty climate with the following features:
      a. Access panel for access and maintenance of internal components.
      b. Knockouts for electrical and piping connections.
   4. Fan Type: Centrifugal and Horizontal
   5. Accessories:
      a. Cabinet Material shall be Stainless steel 304.
      b. Fin Material shall be Polycoat
   6. Performance Requirements:
      a. Shall comply with ASHRAE 15.
      b. Fin Material shall be Polycoat
      c. Comply with safety requirements in UL 484 for assembly of free-delivery, air-source heat pumps.
      d. Comply with all performance parameters stated on the drawing schedule. Heat pump unit must meet or exceed efficiency parameters to be considered as a potential substitution.
   7. Controls: Control equipment and sequence of operation are specified in Section 25 00 00 “Building Automation Systems” Any unique or proprietary controls are
not permissible. All parameters shall be remotely monitored by the BACnet Interface.

8. Units shall be provided with active defrost package.

2.03 COMMERCIAL, ELECTRIC WATER HEATER (EWH-A AND EWH-C);

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Water Heaters.
   c. Lochinvar, LLC.


   a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
      1) NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed Storage-Tank Appurtenances:
   a. The pressure vessel section, including the electrical control panel, shall be mounted on structural supports and be suitably insulated, jacketed, painted and provided with lifting lugs.
   b. The entire unit is to be packaged ready for plumbing and electrical service connections and shall bear the UL listing mark certifying the entire water heater.
   c. The pressure vessel shall be all welded construction and ASME Code Section IV stamped for a working pressure of 125 psi.
   d. The storage vessel shall be carbon steel and lined with seamless Hydrastone cement applied to a minimum thickness of 5/8" on 100% of all interior tank surfaces.
   e. The pressure vessel is to be completely covered with 2" thick energy conservation fiberglass blanket insulation and enclosed in a heavy gauge galvanized steel metal jacket finished in gray hammertone enamel.
   f. The vessel shall be protected by an ASME approved automatic reseating combination temperature and pressure relief valve set at the tank working pressure and 210°F.

5. Electrical:
   a. The heater shall be designed to operate at 460 volts, 3 phase, 60 Hz, with a fused low voltage transformer providing 120 volt to all operating controls.
   b. The immersion heating element(s) shall be high quality copper sheathed and sized to obtain the rated recovery.
   c. Each element circuit is to be independently operated through a definite purpose magnetic contactor having a resistive load rating equal to or exceeding the ampere rating of that particular circuit and shall be protected by individual power fuses rated at approximately 125% of the ampacity of the circuit.
d. Multiple circuit elements shall be provided with a master terminal block for connecting of the incoming power feeds. A safety door interlock switch shall interrupt power to the control circuit when the control panel door is opened.

e. The control thermostat shall be immersion type and shall be consistent with the recovery rate of the heating element as to the number of steps required.

f. A hi-limit control with a manual reset button shall be factory installed to disconnect all ungrounded conductors to the heating element(s) in the event of an over-temperature condition in the storage section.

g. Temperature Control: Adjustable thermostat.

h. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.

i. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

6. Controls: Control equipment and sequence of operation are specified in Section 25 00 00 "Building Automation Systems" BAS package to enabled remote S/S and alarm monitoring shall be specified. All parameters shall be remotely monitored by the BACnet Interface.

7. Capacity and Characteristics:
   a. Capacity:
      1) Refer to Schedules.
   b. Electrical Characteristics:
      1) Refer to Schedules.

2.04 ELECTRIC WATER HEATERS: (EWH-B);

1. Comply with Energy Conservation Standards, Title 24 approved, UL Listed, ASME tank construction. Refer to schedule on the Drawings for capacities, recovery rates and electrical characteristics.

2. Water Heater: Internal fusing glass-lined storage tank, 125 pounds per square inch working pressure for 65-gallons capacity equipped with multi-anode system consisting of magnesium or aluminum anode and European style power anode, jacketed and insulated to meet ASHRAE 90.1 standards, 3 years’ warranty; similar to “Model DSE-65” by A.O. Smith, or approved specified equivalent by Bradford White, Lochinvar.

3. Immersion Heaters: Medium watt density elements in each immersion heater with Incoloy sheathing and ceramic terminal block. KW capacities and voltages shall be as scheduled on the Drawings.

4. Tank Features:
   a. Construction: Manufactured and stamped in accordance with ASME Code Section IV, hydrostatically tested at 225 psi minimum, and National Board Registered for 150 psi working pressure.
   b. Tank shall be cathodically protected with powered anodes.
   c. Liner: Glass, with an alkaline borosilicate composition fused to steel at 1600 degrees F.
   d. Hand-hole clean-out.
   e. Controls compartmented with hinged door enclosing:
      1) 120-volt control circuit transformer
      2) Terminal block for power
3)  Magnetic contactors rated for 100,000 cycles
4)  Immersion type operating thermostat for each immersion heater
5)  Immersion reset high-limit cut-off at 190 degrees F with manual reset
6)  Power circuit fusing where applicable to meet NEC
7)  Solid state modulating step controller for multiple immersion heaters
8)  Safety door interlock, which prevents opening of control panel when heater power is energized
9)  Override switches
10) Indicating/Pilot lights
11) Pressure limit switches
12) Programmable economy-mode operation

5. Insulation: Factory-installed foam insulation with heat loss not to exceed ASHRAE Standard 90.1 and steel enclosure cover with factory-baked enamel finish over bonderized undercoat.

6. Accessories:
a. Anodic protection.

7. Factory-installed AGA/ASME rated temperature and pressure relief valve set at relief pressure of 125 psi.
a. Low water cut-off probe to prevent energizing elements in the event of low water condition.

8. Domestic water heater shall be seismically braced as per Section 22 05 48 – Vibration Isolation and Seismic Restraints for Plumbing.

2.05 STORAGE TANK ST-1 AND ST-2
1. Heavy duty 2" thick fiberglass blanket insulation covers 100% of the pressure vessel for maximum operating efficiency and minimal standby heat loss
3. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
4. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
5. Heavy gauge galvanized steel protective jacket with both top and bottom heads keeps insulation in place and protected to ensure high efficiency during operation
6. Entire vessel is supported on heavy duty integrally welded steel supports for sturdy floor mounting
7. Full five (5) year Non Pro-Rated tank warranty and one (1) year electrical component warranty
8. Bronze ASME rated combination temperature and pressure safety relief valve set at the vessel working pressure and 210°F
9. All welded carbon steel vessel designed and built in strict accordance with the ASME Code Section IV and stamped, certified and registered with the National Board of Boiler and Pressure Vessel Inspectors
10. All internal tank surfaces are lined with a minimum of 5/8" thick Hydrastone cement for superior protection and tank longevity
11. Designed for 125 psi working pressure and hydrostatically tested at 188 psi (11/2 times the WP)
12. Manway 12"x16" size.
2.06 MISCELLANEOUS HEATING SYSTEM ACCESSORIES

1. Accessories:
   a. 3/4-inch NPT copper immersion well with clamp; select for applicable insulation thickness.
   c. Field-addable setpoint lock.

2. Relief Valves:
   a. Pressure and Temperature Relief Valve:
      1) Bronze body and spring and diaphragm combination pressure and temperature type relief valves with test lever and automatically reseating type thermostatic element. Tested under ANSI Z 21.22b with ratings as certified and listed by AGA and rated relief capacities greater than water heater's BTU per hour input rating; by Watts.
   b. Vacuum Relief Valve:
      1) Conformance with ANSI Z21.22b, CSA certified. Brass body and include a protective cap; “Model N36-M1” by Watts or “VR-10” by Wilkins. Number “40L” by Watts or “TP220” by Wilkins for higher BTU per hour input ratings.

3. Thermal Expansion Tank:
   a. Vertical steel expansion tank constructed and designed per ASME Code Section VIII, 125 psi working pressure, steel outer shell, rigid polypropylene liner, heavy-duty butyl rubber diaphragm and non-ferrous system connection tapping, suitable for potable hot water. Refer to schedule on the Drawings for size; by Amtrol, Bell and Gossett, or Wilkins

PART 3 - EXECUTION

3.01 COMMERCIAL ELECTRIC DOMESTIC WATER HEATER INSTALLATION

1. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices as specified.
2. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 22 05 23 “General Duty Valves for Plumbing Piping” and comply with requirements for thermometers specified in Section 22 05 19 “Meters and Gages for Plumbing Piping.”
3. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
4. Fill electric, domestic-water heaters with water.
5. Charge domestic-water compression tanks with air, as required.

3.02 SEQUENCE OF OPERATION AIR SOURCE HEAT PUMPS (HP) ELECTRIC WATER HEATERS (EWH-A & EWH-C).
   a. If Temperature Sensor in EWH-A <= 115°F for 1 minute, turn on 1 Heat Pump.
   b. If Temperature Sensor in EWH-A <= 80°F for 1 minute, turn on all 3 Heat Pumps.
   c. If Temperature Sensor in EWH-A <= 115°F, immediately turn on all 3 Heat Pumps.
   d. If Heat Pump Entering Water Temperature >= 120°F turn off all Heat Pumps.

B. A sequence of operation settings for a multi-stage heat pump systems HP-C-1, HP-C-2 and EWH-C. (Handled by internal heat pump control logic).
   a. If Temperature Sensor in EWH-C <= 115°F for 1 minute, turn on 1 Heat Pump.
   b. If Temperature Sensor in EWH-C <= 80°F for 1 minute, turn on 2 Heat Pumps.
   c. If Temperature Sensor in EWH-C <= 115°F, immediately turn on 1&2 Heat Pumps.
   d. If Heat Pump Entering Water Temperature >= 120°F turn off all Heat Pumps.
2. If neither heat pumps HP-C-1 & HP-C-2 are in alarm status, the EWH-C Electric Resistance Heater shall remain off.
3. If either heat pumps HP-C-1 & HP-C-2 are in alarm status, turn on the EWH-C Electric Resistance Heater.

3.03 CONNECTIONS
1. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.04 IDENTIFICATION

1. Identify system components. Comply with requirements for identification specified in Section 22 05 53 “Identification for Plumbing Piping and Equipment.”

3.05 FIELD QUALITY CONTROL

1. Perform tests and inspections.
   a. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
   b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

2. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 “Quality Requirements” for retesting and reinspection requirements and Section 01 73 00 “Execution” for requirements for correcting the Work.

3. Prepare test and inspection reports.

3.06 ADJUSTING – COMMERCIAL ELECTRIC DOMESTIC WATER HEATER.

1. Adjust initial temperature set points.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to Project during other-than-normal occupancy hours for this purpose.
   a. Factory representative must participate in the Commissioning process. A minimum of two of these visits shall be dedicated to supporting functional testing of the equipment in the Commissioning process.

3.07 DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain water heaters.

END OF SECTION
SECTION 22 42 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Water Closets.
2. Urinals.
3. Lavatories.
5. Laundry Sink.
7. Emergency Shower.
8. Mop Sinks.
10. Drinking Fountains and Bottle Filling Station.

B. Related Requirements:
1. Section 01 81 13 “Sustainability and LEED – V4 Requirements” for sustainability requirements.
2. Section 22 11 16 – “Domestic Water Piping”.
3. Section 22 11 17 – “Recycled Water Piping”

1.03 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

B. Remote Water Closet: Located more than 30 feet (9.1 m) from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. Include construction details, material descriptions, dimensions of individual components and profiles, clearances, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
1. LEED Submittal Requirements: Submit for Sustainability Consultant’s review.
2. GREEN BUILDING MATERIAL CERTIFICATION FORM (GBMCF):
   a. Each material submittal shall include a completed GBMCF per Section 018115 and required backup documentation.
   b. All products must comply with LEED + WELL Material Performance Requirements per Section 018120.
   c. All products shall be meet Environmental Procedures for Hazardous Materials per Section 013543
   d. General requirements environmentally restricted work per Section 013542

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.
   2. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed, but no fewer than one of each type.
   3. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.01 SUSTAINABILITY MATERIAL PERFORMANCE

A. All products must comply with LEED + WELL material performance requirements per section 018120.

2.02 GENERAL REQUIREMENTS

A. Body Materials:
   1. Vitreous china fixtures shall be of highest quality, non-absorbent, hard-burned, and vitrified throughout.
   2. Enameled ware shall be quality cast iron of uniform thickness and density, glazed to uniform depth and high gloss rubbed smooth, without chips or flaws, craze, or cracks, and completely acid resisting.
   3. Stainless-steel fixtures shall be 302/304 types of non-corrosive steel, 18 gage (1.20 mm) self rim for cabinet sinks, 14 gages (2.0 mm) for free standing compartment type sinks. Sink material shall have satin finish and cover corners, with faucet holes punched to match specified faucet fitting.
   4. Insulation for traps and supplies shall be molded closed cell vinyl insulation and shall meet ASTM E84 for flame and smoke spread. Insulation shall be vandal resistant.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 WATER CLOSETS

A. All water closet and flushometer combinations shall have a Maximum Performance Test (MaP) score of 800 or greater when the flushometer is tested with the water closet.

B. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

C. Wall Hung (WC-1 and WC-2):
   1. Fixture: white vitreous china, siphon jet, elongated bowl, 1.1 gal (4.2 L) per flush, NPS 1-1/2 top spud inlet.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard.
         2) Zurn Industries, LLC.
         3) Sloan Valve Company.
         4) Or approved equal.
   2. Flushometer Valve: chrome plated exposed, sensor activated, battery operated, diaphragm flushometer, brass body with corrosion resistant components, integral check stop and backflow preventer, 125 psig (860 kPa) minimum pressure rating.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard.
         2) Sloan Valve Company.
         3) Or approved equal.
      b. Standard: ASSE 1037.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Bemis Manufacturing Company.
         2) Or approved equal.
   4. Water Closet Carrier: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
      a. Manufacturers: Subject to compliance with requirements, provide products by the following:
         1) Zurn Industries, LLC.
         2) J.R. Smith.
         3) Or approved equal.
b. Standard: ASME A112.6.1M.

2.04 URINALS:

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

B. Wall Hung (UR-1 and UR-2):
   1. Fixture: white vitreous china, washout type with extended shields, integral trap, 0.125 (0.45 L) per flush, NPS ¾ (DN 20) top inlet spud, NPS 2 (DN 50) back outlet.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard.
         2) Zurn Industries, LLC.
         3) Sloan Valve Company.
         4) Or approved equal.
   2. Flushometer Valve: chrome plated exposed, sensor activated, battery operated, diaphragm flushometer, brass body with corrosion resistant components, integral check stop and backflow preventer, 125 psig (860 kPa) minimum pressure rating.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard.
         2) Sloan Valve Company.
         3) Or approved equal.
      b. Standard: ASSE 1037.
   3. Type I Urinal Carrier:
      a. Manufacturers: Subject to compliance with requirements, provide products by the following:
         1) Zurn Industries, LLC.
         2) Or approved equal.
      b. Standard: ASME A112.6.1M.

2.05 LAVATORIES

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

B. Undermounted (LAV-1):
   1. Bowl: white vitreous china, oval under-mount with rear overflow, overall dimension 19-¼” x 15-3/4” x 5 ½” deep, ADA-compliant design.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard.
         2) Kohler Co.
         3) Or approved equal.
   2. Faucet: 4” Trim Plate, Battery Power Supply, Below Deck Manual Mixing Valve, Polished Chrome Finish, 0.35 gpm, Multi-Laminar Spray, Infrared Sensor, Battery-Powered Deck-Mounted Low Body Faucet. ADA Compliant,
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
ADDENDUM NO. 1

PLUMBING FIXTURES

1) Sloan Inc.
2) TOTO Inc.
3) Or approved equal.
4) Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
   b. Thermostatic Mixing Valve “Model 270-LF” by Leonard.

3. Supply Kit: Chrome plated brass stops with stuffing box, full turn brass stem, chlorine- and chloramines-resistant replaceable washers, certified to 125 psi line pressure; “LF175LKDF” by McGuire:
   a. Chrome plated copper risers, 12 inches, compression.
   b. Chrome plated wall escutcheon flange: deep flange – bell type – wrought brass or shallow flange – wrought brass with set screw.
   c. Inlet: ½ inch, IPS, as required for connection to faucet supplies.
   d. Outlet: ½ inch, IPS, as required for connection to faucet supplies.
   e. Stop valve handles: chrome plated brass cross.
   f. ½ inch chrome plated brass supply tube from female ½ inch IPS water supply rough-in to stop valve.

4. Drain: Cast brass chrome plated drain assembly with open grid strainer, 17 gauge, 1.25 inch O.D. tailpiece; “155A” by McGuire

5. Trap:
   a. Standard: 1.25 inch by 1.5 inch “P” Trap chrome plated cast brass “P” Trap body with cleanout, with 17 gauge seamless tubular wall bend, cast brass slip nuts with steel, brass wall escutcheon flange; “8902C” by McGuire.

6. Piping Insulation: White, seamless and antimicrobial, closed cell vinyl insulation systems, conforming to ADA article 4.19.4 and BOCA P 1203.4, covering hot and cold angle stops and water supplies, lavatory drain and “P” Trap assembly; secured without exposed plastic ties; by Truebro, or “ProWrap” by McGuire.

C. Wall Mounted (LAV-2):
1. Bowl: white vitreous china, 20-1/2” x 18-1/4” x 4” deep, faucet holes center punching, ADA-compliant design.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) American Standard.
      2) Or approved equal.

2. Faucet: 4” Trim Plate, Battery Power Supply, Below Deck Manual Mixing Valve, Polished Chrome Finish, 0.35 gpm, Multi-Laminar Spray, Infrared Sensor, Battery-Powered Deck-Mounted Low Body Faucet. ADA Compliant,
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Sloan Inc.
      2) TOTO Inc.
      3) Or approved equal.
      4) Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
   b. Thermostatic Mixing Valve “Model 270-LF” by Leonard.

3. Floor mounted Lavatory Carrier:
   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1) Zurn Industries, LLC.
      2) Or approved equal.
   b. Standard: ASME A112.6.1M.
4. Supply Fittings: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange, chrome-plated-brass supply stops, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

5. Waste Fittings: grid type with NPS 1-1/4 (DN 32) offset and straight tailpiece, chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-(0.83-mm-) thick brass tube to wall; and chrome-plated, brass or steel wall flange.

6. Piping Insulation: White, seamless and antimicrobial, closed cell vinyl insulation systems, conforming to ADA article 4.19.4 and BOCA P 1203.4, covering hot and cold angle stops and water supplies, lavatory drain and “P” Trap assembly; secured without exposed plastic ties; by Truebro, or “ProWrap” by McGuire.

2.06 KITCHEN SINK (SK-1):

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.

1. Bowl: 18-gauge, Type 304 stainless-steel single compartment, top mount ADA sink, overall sink dimension of 25 inches long by 22 inches wide by 6½ inches deep, undercoated bowls, mounting clips, screws and undermount clamps for casework countertop thickness of 1.25-inch to 1.5-inch, and 4-hole punch; ADA-compliant design.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkay Inc.
      2) Or approved equal.

2. Faucet: Single handle top mount mixing faucet with swivel pull-out spray spout, aerator and 1.5 gpm maximum flow restrictor at 60 psi; ADA-compliant design.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkay Inc.
      2) American Standard;
      3) Or approved equal.
      4) Standards: ASME A112.18.1/CSA B125.1 and UL 1951.

3. Supplies:
   a. Chrome plated wheel handle angle or straight supply as required with flexible chrome plated copper risers or stainless-steel connector with NSF and FDA Listed non-toxic synthetic polymer core flexible riser of length, size and style of connector required for connection to faucet supply tubes and cast brass set screw wall escutcheon.

4. Strainer: Basket strainer or offset type drain as required for installation; “LK-35” by Elkay.

5. Trap: 1.5-inch by 1.5-inch chrome plated cast trap with 17-gauge tubing waste to wall, cleanout plug and chrome plated cast brass set screw wall escutcheon; “8912-F” by McGuire.

6. Piping Insulation: White, seamless and antimicrobial, closed cell vinyl insulation systems, conforming to ADA article 4.19.4 and BOCA P 1203.4, covering hot and cold angle stops and water supplies, lavatory drain and “P” Trap assembly; secured without exposed plastic ties; by Truebro, or “ProWrap” by McGuire.
ADDENDUM NO. 1
PLUMBING FIXTURES
D-4014 Diablo Valley College P/K Complex

HMC Architects

2.07 LAUNDRY SINK (LS-1):

A. Mounting Height: Handicapped/elderly according to ICC/ANSI A117.1.
   1. Bowl: 18-gauge, Type 304 stainless-steel single compartment, wall mount ADA sink, over-all sink dimension of 22 inches long by 19 ½ inches wide by 6 inches deep;
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Elkay Inc.
         2) American Standard;
         3) Or approved equal.
   2. Faucet: Sink Faucet for hot and cold water, wall-mounted with 4" fixed centers, chrome plated. Rigid/swing, double-bend spout, 6-1/4" center-to-center. 1.5 GPM (5.7 L/min) pressure compensating Softflo aerator. 4" metal, vandal-proof, wristblade handles with sixteen-point, tapered broach and secured blue and red index buttons. Ceramic quarter-turn cartridge, features square, tapered stem. ½" NPSM supply inlets. ADA Compliant.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Chicago Faucets;
         2) Or approved equal.
   3. Supplies:
      a. Chrome plated wheel handle angle or straight supply as required with flexible chrome plated copper risers or stainless-steel connector with NSF and FDA Listed non-toxic synthetic polymer core flexible riser of length, size and style of connector required for connection to faucet supply tubes, and cast brass set screw wall escutcheon.
   4. Strainer: Basket strainer or offset type drain as required for installation; “LK-35” by Elkay.
   5. Trap: 1.5-inch by 1.5-inch chrome plated cast trap with 17-gauge tubing waste to wall, cleanout plug and chrome plated cast brass set screw wall escutcheon; “8912-F” by McGuire.
   6. Piping Insulation: White, seamless and antimicrobial, closed cell vinyl insulation systems, conforming to ADA article 4.19.4 and BOCA P 1203.4, covering hot and cold angle stops and water supplies, lavatory drain and “P” Trap assembly; secured without exposed plastic ties; by Truebro, or “ProWrap” by McGuire.

2.08 MOP SINK (MS-1):

A. Floor mounted
   1. Basin: Dimensions as shown on architectural drawings, one piece, floor mounted, enameled cast iron, 28”x28”x13”, corner model with 3 inch outlet and the following accessories:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Standard;
         2) Or approved equal.
2. Faucet: Exposed yoke wall mount utility faucet, Combination hose end faucet with brass vacuum breaker, integral stops, pail hook, top brace and rough chrome plated brass body and handle construction;
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) American Standard;
      2) Or approved equal.
      3) Standards: ASME A112.18.1/CSA B125.1 and UL 1951.

2.09 SHOWERS

A. Commercial Shower (SH-1):
   2. Individual Pivoting Wall Shower System;
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Bradley Corp.
         2) Or approved equal.
      b. Shower System:
         1) Shower Panel
            a) Shower panel is constructed of 18-gauge stainless-steel. Top and bottom covers are riveted onto shower panel.
         2) Equa-Flow HD Resistant Pressure Balance Mixing Valve: ADA-compliant lever handle,
         3) Hinges
            a) Stainless-steel barrel hinges to mount shower to wall.
         4) Showerhead
            a) Showerhead is chrome plated brass with 1.5 GPM flow control, ball joint and adjustable spray pattern control.
            b) Supply Inlets
               (1) Supply inlets are 24” flexible, stainless-steel hoses with ½” NPT connections. Inlets are accessible through back of shower or through knockouts in the top and bottom covers.

B. Commercial Shower (SH-2) – ADA-compliant design:
   2. Recess Mounted ADA Compliant Wall Shower System;
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Bradley Corp.
         2) Or approved equal.
b. Shower System:
   1) Shower Panel Material:
      a) All exposed materials, except for phenolic seat, are type 304 stainless-steel or polished chrome-plated brass. Shower panel is 14 gauge and grab bar is 18-gauge. Valve bodies are brass casting. Supply hoses are 24” flexible stainless-steel.
      b) Shower panel is constructed of 18-gauge stainless-steel. Top and bottom covers are riveted onto shower panel.
   2) California ADA Compliant:
      a) When installed properly in a 36” x 60” stall (provided by others), the HN200-T24 provides a shower stall designed to comply with all known T24 guidelines on reaches, clearances, and operation. Controls are mounted 40” above the floor to accommodate all users.
   3) Equa-Flow HD Resistant Pressure Balance Mixing Valve: ADA-compliant lever handle,
   4) Diverter Valve:
      a) Lever handle operation for easy transfer of water flow between fixed and hand-held hose spray.
   5) Showerhead:
      a) Showerhead is chrome plated brass with 1.5 GPM flow control, ball joint and adjustable spray pattern control.
   6) Hand Shower
      a) Consisting of hand shower with pause control, a 60” braided stainless-steel flexible hose and post style mounting bracket to hold to shower panel. Elevated in-line backflow preventer with quick-disconnect for flexible hose
   7) Supply Inlets
      a) Supply inlets are 24” flexible, stainless-steel hoses with ½” NPT connections. Inlets are accessible through back of shower or through knockouts in the top and bottom covers.

2.10 EMERGENCY SHOWER (ESEW-1)
   1. Drench shower with horizontal supply.
   2. Impact-resistant plastic shower head is colored bright yellow for high visibility in emergency situations.
   3. Plastic Showerhead w/Stainless Steel Shroud.
   4. Shower pull rod is stainless steel.
   5. Galvanized steel piping is additionally protected with BradTect® safety yellow coating.
   6. High performance corrosion-resistant stainless steel showerhead measures 1½” in diameter.
   7. Spin-Tec drench showerhead features integral 22 GPM flow control, conserving water and helping to accurately size your cold water system.

2.11 WHIRLPOOL BATHTUB

   A. Mobile Whirlpool Bathtub (BT-1):
1. Tank Capacity is 90 gallons.
2. Whirlpool Tank is 46"L x 24"W x 25"D and is seamless welded construction, fabricated from heavy gauge, type 304 stainless steel, polished to a satin finish.
3. Tank rim is reinforced with a concealed stainless steel rod. Tank bottom is seamless, coved (rounded) design for effective cleaning to minimize bacteria buildup.
4. Tank is also provided with an extended stainless steel skirt flush to the floor line to conceal internal drain piping.
5. Tank 2" Combination Drain and Overflow, with a Filler Spout.
6. Turbine Assembly is equipped with Underwriters Laboratory listed 1/2 HP jet pump motor protected with an ABS plastic shell, automatic thermal overload protector, and lifetime-sealed bearings. All parts contacting the water are stainless steel, chrome plated brass or bronze.
  a. Valve included temperature gauge, lockable inlet and outlet ball valves, and vacuum breaker.
  b. Valve shall comply with ASSE 1069, ASSE 1070 standards.
10. Thermometer is provided with a dual scale, adjustable calibration, and a stem inserts into a retainer to prevent rattle during whirlpool agitation.

2.12 DRINKING FOUNTAINS AND BOTTLE FILLING STATION

A. Drinking Fountain and Bottle Filler (DF-1) Interior:
1. Wall-mounted EZH2O Bottle Filling Station & Versatile Bi-Level ADA Cooler Filtered Non-Refrigerated Stainless;
   a. Fixture: Elkay ezH2O® Bottle Filling Station & Versatile Bi-Level ADA Cooler, Filtered Non-Refrigerated Stainless.
2. Electronic Bottle Filler Sensor with Electronic Front and Side Bubbler Pushbar activation.
3. Product shall be Wall Mount (On-Wall), for Indoor applications, serving 2 station(s).
4. Unit shall be certified to UL 399 and CAN/CSA C22.2 No. 120.
5. Unit shall be lead-free design which is certified to NSF/ANSI 61 & 372 (lead free) and meets Federal and State low-lead requirements
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkay Manufacturing Co.
      2) Or approved equal.
6. Unit shall be:
   a. Touchless, sensor-activation.
   b. Visual Filter Monitor: LED Filter Status Indicator for when filter change is necessary.
   c. Filter is certified to NSF 42 and 53 for lead, particulate, chlorine, taste and odor reduction. 3,000 gal. capacity.
   d. Green Ticker: Informs user of number of 20 oz. plastic water bottles saved from waste.
e. Laminar flow provides clean fill with minimal splash.
f. Silver Ion Antimicrobial protection on key plastic components to inhibit the growth of mold and mildew.
g. Real Drain System eliminates standing water.
h. Vandal-resistant, bubblers are one-piece, chrome plated with integral hood guard design to prevent contamination from other users, airborne deposits and tampering.

7. Type I Water Drinking Carrier:
a. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1) Zurn Industries, LLC.
   2) Or approved equal.
b. Standard: ASME A112.6.1M.

B. Drinking Fountain and Bottle Filler (DF-3) Interior:
1. Wall Mount unit is anchored to a wall:
a. Unit shall be lead- free design which is certified to NSF/ANSI 61 & 372 (lead free) and meets Federal and State low-lead requirements
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) Most Dependable Fountain, Inc.
   2) Or approved equal.
c. Receptor Bowl:
   1) One-piece weld construction with MDF standard 304 schedule 10 stainless-steel.
   2) 18-gauge electro-polished stainless-steel bowl. Bowl overlaps pedestal, preventing buildup of residue in visual drinking area. Optional stainless-steel Bowl Strainer recommended for areas with sand.
d. Bottle Filler:
   1) Sanitary recessed nozzle.
e. Stainless-steel anti-squirt head (weighing a pound and a half) mounted with a lock nut and washer to prevent tampering. Lock nut pin holds bubbler in locked position to prevent twisting or turning. The MDF bubbler head has a unique design that features a steady stream trajectory and a built in natural shield from contamination.
   304 stainless-steel with circumference exceeding 8.6”. Mushroom style push bar overlaps and prevents sand and other objects from sticking push bar in the ON position. Stainless-steel bubbler housing standard.
g. Requires less than 5 lbs to operate. Non-cartridge O-ring delivers steady stream of water through an adjustable valve. This valve design is to operate and function at 30 to 80 PSI. Ideal operating pressure is 60 PSI.
h. Maintenance free reinforced nylonbraid tubing that is NSF-61 certified. This tubing is not plastic. It is supplied with a 1/2” MIP threaded inlet with stainless-steel strainer. Union fittings at every connection. Supply line stops above grade. Water Filter is standard on this model.
i. 1 1/2” drain line.

c. Pedestal Mounted Bottle Filler with Bi-Level Drinking Fountain (DF-4) Exterior:
1. Pedestal mounted bottle filler with bi-level bowls;}
a. Fountain is certified to ANSI A117.1, Public Law 111-380 (NO-LEAD), CHSC 116875 and NSF/ANSI 61, Section 9. Fixture meets ADA Requirements.
b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) Most Dependable Fountain, Inc.
   2) Or approved equal.
c. Construction shall be stainless-steel with 18 gage stainless-steel fountain bowls. Pedestal shall have four mounting holes.
d. Access covers shall be secured with vandal-resistant stainless-steel screws.
e. Bottle filler shall be activated by a 9-volt sensor or a pushbutton as standard.
f. Unit shall contain a 100-mesh inlet strainer, lead and cyst filter, 6-AA battery pack and laminar flow spout.
g. Self-closing pushbuttons, needing less than 5 pounds force, shall activate internally mounted valves with adjustable stream regulators.
h. Bubblers shall be stainless-steel with non-squirt feature and operate on water pressure range of 20-105 psig.

2.13 DRINKING FOUNTAIN:

A. Wall Mounted Drinking Fountain (DF-2) Exterior:
   1. General Characteristics:
      a. Unit shall be lead-free design which is certified to NSF/ANSI 61 & 372 (lead free) and meets Federal and State low-lead requirements
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elkay Manufacturing Co.
      b. Or approved equal.
   3. Fixture:
      a. Two-level wall mounted drinking fountain constructed of #18 gauge, type 304, stainless-steel polished to a lustrous satin finish.
      b. Contoured basin minimizes splashing and has exclusive Flexi-Guard® safety bubbler to prevent accidental mouth injuries. Keyed in location to prevent rotation. Easy to operate, fully functional push-buttons are vandal-resistant. Vandal-resistant bottom cover plates included. Flow regulator provides constant stream from 20 to 105 psi water pressure.
      c. ADA Complied.
   4. Type I Water Drinking Carrier:
      a. Manufacturers: Subject to compliance with requirements, provide products by the following:
         1) Zurn Industries, LLC.
         2) Or approved equal.
         3) Standard: ASME A112.6.1M
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General:

1. Install level and plumb according to roughing-in drawings.
2. Install accessible fixtures at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
3. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
4. Install according to manufacturer’s instructions.

B. Water-Closet Installation:

1. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
2. Support Installation:
   a. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
   b. Use carrier supports with waste-fitting assembly and seal.
3. Flushometer-Valve Installation:
   a. Install flushometer-valve, water-supply fitting on each supply to each water closet.
   b. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   c. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
   d. Install actuators in locations that are easy for people with disabilities to reach.
4. Install toilet seats on water closets.

C. Urinal Installation:

1. Support Installation:
   a. Install supports, affixed to building substrate, for wall-hung urinals.
   b. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
   c. Use carriers without waste fitting for urinals with tubular waste piping.
   d. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

2. Flushometer-Valve Installation:
   a. Install flushometer-valve water-supply fitting on each supply to each urinal.
   b. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   c. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
D.  Lavatory Installation:
   1.  Install supports, affixed to building substrate, for wall-mounted lavatories.
   2.  Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 07 19 “Plumbing Piping Insulation.”

E.  Sink Installation:
   1.  Install supports, affixed to building substrate, for wall-hung sinks.
   2.  Set floor-mounted sinks in leveling bed of cement grout.
   3.  Install water-supply piping with stop on each supply to each sink faucet.
      a.  Exception: Use ball valves if supply stops are not specified. Comply with valve requirements specified in Section 22 05 23 “General Duty Valves for Plumbing Piping”.
      b.  Install stops in locations where they can be easily reached for operation.

F.  Drinking Fountain Installation:
   1.  Install recessed drinking fountains secured to blocking in wall construction.
   2.  Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
   3.  Install water-supply piping with shut-off valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 22 05 23 “General Duty Valves for Plumbing Piping”.
   4.  Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

G.  Wall Flange and Escutcheon Installation:
   1.  Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
   2.  Install deep-pattern escutcheons if required to conceal protruding fittings.
   3.  Comply with escutcheon requirements specified in Division 22.

H.  Joint Sealing:
   1.  Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2.  Match sealant color to water-closet color.
   3.  Comply with sealant requirements specified in Division 07.

3.03  CONNECTIONS

A.  Connect fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B.  Comply with water piping requirements specified in Section 22 11 16 “Domestic Water Piping.”

C.  Comply with soil and waste piping requirements specified in Section 22 13 16 “Sanitary Waste and Vent Piping.”

D.  Where installing piping adjacent to fixtures, allow space for service and maintenance.
3.04 ADJUSTING

A. Operate and adjust fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.05 CLEANING AND PROTECTION

A. Clean fixtures and fittings with manufacturers’ recommended cleaning methods and materials.

B. After installation and prior to occupancy, install protective covering for installed fixtures and fittings. Remove protection once Certificate of Occupancy is obtained.

C. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION
SECTION 23 00 00
HVAC GENERAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Division 01.

B. The requirements of the General Conditions and Supplementary Conditions.

1.02 SUMMARY

A. Furnish and install a complete (fully tested, adjusted, and ready for operation) mechanical system and fully automatic indoor space thermal conditioning and ventilation (commonly "HVAC") system with associated controls as described by the Contract Drawings and Specifications.

B. The HVAC systems and design described in the Project documents reflect a building designed for low consumption of energy and water and minimum environmental footprint. Any modifications to the systems described herein shall maintain or improve on the sustainability and energy efficiency features of the project.

C. All design modifications that pertain to system selection, system energy efficiency and energy use, material selection and indoor air quality issues shall require the approval of Integral Group.

D. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

E. Check, verify, and coordinate Work with Contract Drawings and Specifications prepared by all other trades. Include modifications, relocations, and adjustments necessary to complete work or avoid interference with other trades.

F. Where architectural features govern location of Work, refer to Architectural Drawings.

G. Contractor may install additional piping, fittings, and valves, not shown on the drawings, for testing purposes or convenience of installation. Where such materials are installed, they shall comply with the specifications and shall be properly sized for the system and operation. Remove such installed materials when they interfere with design conditions or as directed by the Architect.

H. LEED: This building shall be LEED certified. Contractor and their subs shall provide all relevant support documentation pertaining to the LEED credits that relate to their work.

1.03 CODES AND STANDARDS

A. All work and materials shall be in full accordance with the latest local rules and regulations, applicable sections of the California Code of Regulations, Title 24, State
Fire Marshal, the Safety Orders of the Division of Industrial Safety, the California Electric Code and applicable State requirements. Nothing in these Plans and Specifications is to be construed to permit work not conforming to these requirements.

B. HVAC system installers shall be trained and certified in the proper installation of HVAC systems including ductwork, pipework, and equipment by a nationally or regionally recognized training or certification program. Uncertified persons may perform HVAC installations when under the direct supervision and responsibility of a person trained and certified to install HVAC systems or a contractor licensed to install HVAC systems.

C. Wherever the Specifications call for or describe materials or construction of better quality or larger sizes than are required by the above rules and regulations, these Specifications shall govern. Should there be any direct conflict between the above rules and regulations and the Specifications the rules shall govern.

D. Equipment shall have UL label listing.

1.04 DRAWINGS

A. Layout of the equipment and work is diagrammatic, unless specifically dimensioned. Drawings and details shall be checked for interferences before installing the work. Any interference noted between different drawings, and between drawings and actual field conditions shall be brought to the attention of the Architect and Engineer of Record for a decision. The right is reserved to make any reasonable change in location of equipment without additional expense to the Owner.

B. For purposes of clarity and legibility, drawings are diagrammatic to the extent that many offsets, bends, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Exact routing of piping and ductwork and locations of equipment shall be governed by structural conditions and obstructions. Contractor shall make use of all data in Contract Drawings and Specifications and field conditions.

C. In the event a major re-routing of a system appears necessary, Contractor shall prepare and submit for approval, shop drawings of the proposed rearrangement. Because of the diagrammatic nature and small scale of the Contract Drawings, all necessary offsets, adjustments, and transitions required for the complete installation are not shown. Contractor shall carefully investigate the structural and finish conditions affecting all the Work and shall arrange such Work accordingly, furnishing such fittings, equipment, accessories, etc., as may be required to meet such conditions, at no increase in Contract Sum.

D. The construction documents for this project were prepared by the design team using BIM (Building Information Modeling). Using this software by the design team does not relieve the Contractor from performing the necessary coordination to provide complete, code compliant and operational building systems. The plans and sections provided are diagrammatic and show the design intent, these are not intended to be used for fabrication or installation. Contractor is responsible for generating shop drawings for fabrication that meet the design intent as shown on the Contract Documents. The exact location of the piping, ductwork, electrical and support components are to be determined by the Contractor. All building sections and details provided are for
information only and do not relieve the Contractor from performing final coordination. Contractor is responsible for coordinating with all other trades.

E. All dimensions and locations of equipment, doors, partitions, etc., are to be taken from the architectural plans but shall be verified at the site.

1.05 MECHANICAL SUBMITTAL PROCEDURES

A. See Division 01 “Administrative Requirements”, for submittal procedures.

B. Mechanical and related submittals are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. For DDC Building Automation Systems, see also Division 25 for additional submittal requirements and a detailed submittal schedule.

D. Engineer of Record will review submittals and provide comments within the following timeframe after receipt by the Engineer:
   1. For typical submittals, allow 10 working days.
   2. For large or complex submittals, allow 15 working days. Determination of “large and complex” submittal shall be at the discretion of the Engineer of Record.
   3. Do not send Engineer of Record more than 10 submittals in a contiguous period of 5 working days. If excess submittals are received, review period will be extended as necessary to perform proper review. Submittals will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.
   4. These submittal review periods supersede and take precedence over periods defined in Division 01, unless Division 01 allows for longer review periods.
   5. Submittal review periods shall not be reduced from the times herein except by agreement with the reviewing entity, in advance and in writing.

E. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Use the same identifiers (e.g. equipment tags) used in Contract Drawings.

F. Submittals shall be provided in digital format.
   1. Provide a separate file for each submittal. For submittal packages, provide a separate file for each subsection (e.g. hardware cutsheets and shop drawings for the same Section shall be provided as separate files).
   2. Product cutsheets, test forms and other text documents shall be provided in word searchable digital format. Acceptable formats are MS Word, PDF (generated from another electronic document and word-searchable; scans of paper documents are not acceptable), and HTML; other formats require approval prior to submission.
   3. Drawings and schematics shall be provided in PDF format and in AutoCAD compatible format.
   4. Scanned paper documents are not acceptable
      a. Exception: original signed documents, such as qualifications, inspection certificates, and warranty documents.
5. Hardcopy (paper) submittals are not acceptable and shall not be provided except as noted elsewhere.

6. Submittals provided in the wrong format will be returned without action.

G. Submission and Resubmission Procedure

1. Optional Pre-Submittals: At Contractor’s option, material may be submitted unofficially via email directly to the Engineer of Record for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time, and to provide a venue to discuss technologies, products, designs or implementation strategies that are novel or unique.

2. Each submittal shall have a unique serial number that includes the associated Specification Section followed by a number for each sub-part of the submittal for that Specification Section, such as SUBMITTAL 23 00 00-01. There is no requirement to assign particular serial numbers to any specific submittals – serial number assignment is arbitrary. The only requirements are that the serial numbers be sequential (to avoid confusing gaps) and, most importantly, consistent across all submittal correspondence.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 230000-01 REVISION 1.

4. Submit one copy of submittal in electronic format. Submissions made in the wrong format will be returned without action.

5. Include with each submittal and resubmittal a copy of the relevant specification section(s) noting on each paragraph and sub-paragraph(s) the following:
   a. CONFORMS: Contractor has verified that the submitted product conforms to the noted requirement(s).
   b. CONFORMS AS NOTED: Contractor has verified that the submitted product conforms to the noted requirement(s) by means of being equal to or higher quality and / or performance.
   c. NON-CONFORM: Contractor has verified that the submitted product does not conform to the noted requirement(s) and delineates each deviation from the specification requirements.
   d. NOT APPLICABLE: Contractor has verified that the noted requirement(s), in their opinion do not apply to this product, delineating the reasons for this decision.
   e. Include with each submittal and resubmittal a copy of the relevant specification section(s) the printed name of the contractor reviewer, their signature, the company name, and date of review.

6. Revise submittal
   a. Respond to all comments:
      1) Revise initial submittal to resolve review comments and corrections.
      2) Provide complete responses to comments or suggestions which are not practical to implement in the opinion of the Contractor.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.
   d. Resubmittals that are not responsive to all comments will be returned without action.

7. Resubmit revised submittals until no exceptions are taken.
8. Once submittals are accepted with “No Exceptions Taken” or “Approved As Noted”, provide:
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

H. Submit shop drawings, a list of proposed material and equipment manufacturers and the names of Subcontractors.

I. Shop drawings shall be provided for all mechanical systems for all floors of the building. Mechanical shop drawings shall also be provided for the underslab systems (under the foundation slab) and slab-embedded systems such as hydronic radiant loops and controls.

J. Materials and methods with which the words “for approval” or “approved” are used, and materials and methods which differ from those specified, shall be submitted.

K. Prepare and submit shop drawings, sections, details and diagrams to minimum scale 1/4” = 1'-0". Pump rooms and mechanical rooms shall be 1/2” = 1'-0” minimum scale. Drawings shall be coordinated, dimensioned and indicate equipment, pipe, duct, fire protection, and electrical in relation to architectural and structural features. Include minor piping, drains, air vents, etc. Indicate exact locations and elevations of valves, piping specialties, access doors, dampers, etc. Electronic submittal is encouraged.

L. Submit manufacturer’s specifications, product source, data sheets, certified equipment drawings and installation instructions, including installation dimensions, clearances, weights, materials, finishes, color selection, accessories, acoustical characteristics, capacity and full load and part load performance curves; complete with electrical data, motor horse power, kW; motor efficiency, amperage, voltage phases and wiring diagrams. Identify the particular specification section number, paragraph and equipment identification number per equipment schedule. Note that suppliers (wholesalers and distributors) data sheets are not acceptable unless they are also manufacturers of the product being submitted.

M. Fan and pump systems, with equipment in parallel, shall have performance curves noting single equipment operation and all iterations of additional equipment.

N. Certified Equipment Drawings (8-1/2” x 11” sheets) shall be indexed in accordance with Specification Section. Drawings to be submitted at a later date shall be marked with a page as a placeholder for insertion when submitted. The original submittal shall note which shop drawings will be submitted later. Marked-up catalogs are not acceptable and will be returned without action. Electronic submittal is required.

O. Engineer of Record’s review of submittals is for limited purpose of verifying conformance with information given and design concept expressed in Contract Drawings and Specifications. Engineer’s review is not for purpose of determining accuracy or completeness of items such as dimensions and quantities, which remain responsibility of Contractor.
P. Contractor shall not commence with fabrication or installation of any equipment or system until the associated submittals have been approved by the Engineer of Record and returned with "no exceptions" taken. Contractor shall be solely liable for any costs incurred from starting fabrication before approved submittals are returned.

Q. All final approved submittals and equipment datasheets shall be provided, in PDF format, to the owner as part of the as-built drawing set and shall be text searchable.

1.06 COORDINATION DRAWINGS

A. Utilize the latest version of 3D AutoCAD, Navisworks, and/or Revit software for the Coordination Drawings. No proprietary software of any kind shall be used other than that indicated. Drawing paper size shall not be larger than FULL SIZED Contract Drawings, and in no case larger than 30” x 42”. Coordinate available space with ALL other trades involved.

B. Provide Coordination Drawings in digital electronic format. Provide both native file format (AutoCAD, Navisworks, or Revit) and PDF format files. Hardcopy drawings are not acceptable.

C. These drawings are to show registers, grilles, diffusers, duct sizes, elevation of bottom of duct, pipe sizes, valves and accessories, elevation of bottom of pipe, all elevations of materials and/or systems throughout each floor inclusive of hanger components, seismic bracing if applicable, and any component of construction that impacts vertical and/or horizontal space. In addition, the locations of all valves, dampers, and other items requiring access for service and maintenance are to be shown. The drawings are to also show electrical, structural beams, architectural bracing, structural bracing, ceiling heights, access doors, walls, floor to floor dimensions, columns, doors and other major architectural and structural features as shown on the architectural and structural drawings. Where the routing of work differs from that indicated on the Contract Drawings, such areas are to be indicated by highlighting with a note describing the reason for the change.

D. Rerouting of any system or part thereof shall be submitted separately in order to obtain concurrence of the Engineer of Record. Submitted rerouting must include fully documented proposed solutions with all trades coordinated. Contractor is fully responsible for coordination of systems included herein. Any effort by Engineer of Record beyond answering Contractor’s questions will be at Contractor’s expense, including attending coordination meetings, review of interim plans, or review of incomplete questions (routing issues without suggested solutions).

E. The Contractor and subcontractors are responsible to review and resolve any real or apparent interferences or conflicts as indicated by the coordination drawings produced by each trade.

F. After all conflicts or interferences are resolved, develop a final composite drawing showing the agreed upon routing, layout and juxtaposition of all duct work, conveyers, piping, major conduit, valves, panels, lighting fixtures and all other major mechanical, plumbing and electrical installations. In the preparation of all the final Coordination Drawings, large scale details as well as cross and longitudinal sections are required to fully delineate all conditions.
G. Submit the Coordination Drawings as digital electronic files to Engineer of Record for review and comment, as indicated under “Shop Drawings” above. Coordination Drawings shall be digitally signed-off by all other trades.

H. Contractor shall not commence with fabrication or installation of any equipment or system until the associated shop drawings have been reviewed and returned by the Engineer of Record. Engineer’s review of shop drawings shall not be taken as approval of their contents. Contractor shall be solely liable for any costs incurred due to deviations from the Contract Drawings.

I. No extra compensation will be paid for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination between all trades involved. If any improperly coordinated work, or installed work that is not in accordance with the approved coordination composites, or is specifically noted by the Architect or Engineer of Record for a valid reason, necessitates additional work by the other trades, the costs of all such additional work is to be borne solely by the Contractor.

J. All changes in the scope of work due to revisions formally issued and approved are to be shown on both the individual subcontractor’s Shop Drawings and the Coordination Drawings.

1.07 REQUESTS FOR INTERPRETATION AND CLARIFICATION

A. See Division 01 “Project Management”, for RFI procedures and forms.

B. Mechanical RFIs are, in addition, subject to the requirements of this Article. In the event of a conflict between the requirements of Division 01 and this Article, the requirements of this Article shall supersede and take precedence over those of Division 01.

C. Limit each RFI to a single issue or group of related issues.

D. Each RFI shall include a workable no-cost or lowest cost solution recommendation by Contractor.

E. Allow 3 working days from time of RFI receipt by Engineer of Record for review and response.

F. Do not send Engineer of Record more than 10 RFIs in a contiguous period of 5 working days. If excess RFIs are received, review period will be extended as necessary to provide a professional response. RFIs will be reviewed in priority determined by Engineer of Record in consultation with Architect and Contractor.

1.08 MATERIALS AND SUBSTITUTIONS

A. Comply with Division 01 “Product Requirements”.

B. Requests for product or equipment substitution shall be accompanied by a marked up copy of the Engineer of Record’s original specification. For each specified product
feature or requirement, Contractor shall note the equivalent feature or attribute of the proposed substitute product or equipment.

C. Shop drawings of proposed material and equipment that differ from the specified materials and equipment, shall be accompanied by drawings that define changes. These drawings shall show modifications of architectural, plumbing, electrical and mechanical work required by the proposed materials and equipment, such as relocation of flues, drains, revised electrical circuits, relocation of roof or wall penetrations, revised foundations, etc.

1.09 COORDINATION WITH OTHER WORK

A. Contractor performing Work under this Section shall become thoroughly familiar with the Drawings and Specifications. Contractor shall adjust the Work to conform with the conditions shown on these drawings to provide the best possible assembly of the combined Work.

B. Obtain necessary information from the other trades regarding location of their work in order that the Work in this Section may be placed in correct position.

C. The inclusion and proper location of supports, pads, sleepers, openings, anchorages, etc. provided by others is the responsibility of the Contractor under this Section. Cutting and/or boring shall be permitted under this Section only with the written approval of the Architect.

D. It shall be the Contractor’s responsibility to coordinate and have provided by other trades where not covered by the Contractor’s scope of work, all electrical wiring and power to equipment, controls and devices, and any other work from other trades as required to provide fully functioning HVAC systems per the Contract Drawings and Specifications.

E. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified with no cost impact to the owner. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.10 MANUFACTURER’S DIRECTIONS

A. Manufacturer’s directions shall be followed in cases where the manufacturers of articles used in this contract furnish directions covering points not shown in the Contract Drawings and Specifications.

1.11 PROTECTION OF WORK

A. Equipment and materials shall be stored on dunnage and remain wrapped at all times until installed.

B. Duct and piping shall be remain capped during delivery and storage.
C. During installation, all installed duct and piping shall be capped and protected at the end of each working day.

D. Equipment shall be protected from weather and stored in an enclosed, indoor location.

E. Until final acceptance of the work, protect materials from damage and provide adequate and proper storage facilities. Replace damaged or defective work, material, and equipment before requesting final acceptance.

1.12 WORKMANSHIP

A. Equipment and materials shall be installed in a neat and workmanlike manner. Materials and equipment not so installed shall, upon order of the Architect or Engineer of Record, be removed and replaced in a satisfactory manner, without change in Contract Sum or additional cost to the Owner.

1.13 CLOSING IN UNINSPECTED WORK

A. Do not allow or cause any work to be covered up or enclosed until it has been inspected, tested, and accepted by the Architect, Engineer of Record, and/or Commissioning Authority.

B. Any work enclosed or covered-up prior to inspection and testing shall be uncovered. After the work has been tested, inspected and accepted, repair such materials as may be necessary to restore disturbed work to its original and proper condition at no extra cost to the Owner.

1.14 EQUIPMENT ANCHORING

A. Equipment shall be securely anchored to the building structure to prevent shifting or overturning during earthquakes.

1.15 PRELIMINARY OPERATION

A. Under this section, Contractor shall supervise and direct preliminary operation of systems should the Owner demand that any portion of the plant, apparatus, or equipment be operated previous to the final completion and acceptance of the work. Expenses for such preliminary operation will be paid by the Owner. Such preliminary operation or payment shall not be construed as an acceptance of the work.

1.16 “AS-BUILT” DRAWINGS

A. Comply with Section Division 01 “Project Closeout”.

B. For DDC Building Automation systems, see also COMPLETION REQUIREMENTS in Part 1 of SectDivision 25-50-00 for additional as-built and closeout submittal requirements.

C. As-built drawings shall be furnished in an electronic format. Provide in drafting software (AutoCAD or Revit) native format and also in PDF format.
1.17 FINAL INSPECTION

A. At the time of final inspection, a service representative shall be available to make final adjustments.

1.18 FINAL OPERATION

A. After acceptance of the installation, instruct the Owner’s Representative in operation and maintenance, for a period of three (3), non-consecutive working days at a time requested by the Owner during the first year of warranty.

B. At the beginning of the instruction period, deliver to the Owner three (3) copies of a durable binder as described under “Operating Instructions”.

1.19 OPERATING INSTRUCTIONS

A. The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these Specifications.

B. Division 23 shall compile and prepare documentation for all equipment and systems covered in Division 23 and deliver this documentation to the General Contractor for inclusion in the O&M manuals prior to the training of Owner personnel.

C. In addition, DDC Contractor shall provide O&M material as required by “Completion Requirements” in Part 1 of SectDivision 25 50 00.

D. Provide a summary of operating sequences (start-up, normal run, and shut-down), and control shop drawings in the main mechanical room.

E. Provide three (3) complete sets of Operating Instructions. These instructions shall include brochures, diagrams, maintenance, and operating instructions and parts lists.

F. Provide a copy of the O&M manuals to the Commissioning Authority for review.

1.20 TRAINING OF OWNER PERSONNEL

A. The General Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The Commissioning Authority (CxA) shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

C. The Mechanical Contractor shall have the following training responsibilities:
   1. Provide the CxA with a training plan two weeks before the planned training.
   2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, air conditioning units, air handling units, fans, boilers, terminal units, controls, water treatment systems, etc.
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The DDC Contractor shall attend sessions other than the DDC System training, as requested, to discuss the interaction of the DDC System as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:
   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discussion of relevant health and safety issues and concerns.
   d. Discussion of warranties and guarantees.
   e. Common troubleshooting problems and solutions.
   f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discussion of any peculiarities of equipment installation or operation.
   h. Instruction in the use of equipment controls that are integral to equipment or are provided by the equipment manufacturer, such as VRF System controls. This is in addition to and separate from DDC System training (see below) and does not replace or satisfy the requirement for such training, if specified. Equipment controls training shall include at least the following:
      1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system and any interface with security and communication systems.
      2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
3) If system supports trending, all trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.

4) Every screen shall be completely discussed, allowing time for questions.

5) Use of keypad or plug-in laptop computer for mobile control access.

6) Use of remote access to the system via phone lines or networks, if applicable.

7) Graphics generation, if applicable.

8) Point database entry and modifications, if applicable

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

10. The Mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

D. DDC Contractor.

1. See TRAINING in Part 3 of SectDivision 25 50 00 for DDC System training requirements and DDC Contractor obligations.

2. DDC Contractor shall coordinate with Mechanical Contractor and Commissioning Authority regarding training on equipment-integrated or manufacturer-supplied control systems as described above. Such training is the responsibility of Mechanical Contractor but may be adopted by DDC Contractor by mutual agreement, to facilitate a more integrated training experience.

E. DDC Contractor.

1. Not applicable due to no DDC Building Automation System.

2. Mechanical Contractor is responsible for training on equipment-integrated or manufacturer-supplied control systems as described above.

F. E. Test and Balance (TAB) Contractor. The TAB Contractor shall have the following training responsibilities:

1. TAB Contractor shall meet with facility staff after completion of TAB and instruct them on the following:
   a. Go over the final TAB report, explaining the layout and meanings of each data type.
   b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
   c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
e. Other salient information that may be useful for facility operations, relative to TAB.

1.21 WARRANTY

A. In accordance with Division 01 Project Closeout requirements, Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. Contractor shall leave entire installation in complete working order and free from defects in material, workmanship, or finish.

C. Warranty all materials, equipment, apparatus, and workmanship to be free of defective materials and faulty workmanship for a minimum period of one (1) year from date of Certificate of Occupancy, or per Division 01, whichever is longer.

D. Warranty also services including instructions, adjusting, testing, noise, balancing, etc.

E. For each piece of equipment or device with a manufacturer’s warranty in excess of one year, Contractor shall furnish certificate of manufacturer’s warranty and contact information for manufacturer’s warranty service. Contractor shall also provide a list or table of all equipment with warranties exceeding one (1) year in duration.

F. Provide new materials, equipment, apparatus, labor and/or service, and support to correct or replace that determined by the Owner to be defective or faulty.

G. The Owner reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the guarantees or relieving responsibility during the guarantee period.

H. For DDC System, see WARRANTY and WARRANTY MAINTENANCE in Part 1 of SectDivision 25.50.00. DDC System warranty commences upon the acceptance of COMPLETION REQUIREMENTS described in Part 1 of that Section, which may occur after the Certificate of Occupancy.

I. After a period of 90 calendar days from date of acceptance of systems by Owner, provide, at no cost to the Owner, one service mechanic for an 8-hour period over as many working days as required to repair, replace any latent deficiency.

1.22 SUBMITTALS

A. Welding certificates.

1.23 ACTION SUBMITTALS

A. Product Data: For each type of product in Part 2.

1.24 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, “Structural Welding Code--Steel.”
B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.01 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.


2.02 SLEEVES

A. Galvanized-Steel Sheet: 0.0239 inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated “wall pipe” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PE or PP: Reusable, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.03 SLEEVE SEAL SYSTEMS

A. Manufacturers:
   1. Link-Seal
   2. Advance Products & Systems, Inc.
   3. CALPICO, Inc.
   4. GPT; an EnPro Industries company.
   5. Metraflex Company (The).
B. Description:
  1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
  2. Designed to form a hydrostatic seal of 20-psig.
  3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
  4. Pressure Plates: Carbon steel.
  5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

2.04 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening. Polished chrome-plated finish.
  1. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass.
  2. One-Piece, Cast-Brass Type: With set screw.

2.05 GROUT

A. Description: ASTM C1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
  2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1 inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
  1. Permanent sleeves are not required for holes in slabs formed by molded-PE or PP sleeves.
  2. Cut sleeves to length for mounting flush with both surfaces.
    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level.
  3. Using grout, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
  1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for fire-stopping and fill materials specified in Division 07.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.03 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. Exterior Concrete Walls Above Grade: Cast-iron sleeves or Galvanized Steel pipe sleeves.
   2. Exterior Concrete Walls Below Grade: Cast-iron pipe sleeves with sleeve-seal system or Galvanized Steel pipe sleeves with sleeve-seal system.
      a. Select sleeve size to allow for 1 inch annular clear space between piping and sleeve for installing sleeve-seal system.
   3. Concrete Slabs-on-Grade: Piping Smaller Than: Cast-iron pipe sleeves with sleeve-seal system or galvanized Steel pipe sleeves with sleeve-seal system.
      a. Select sleeve size to allow for 1 inch annular clear space between piping and sleeve for installing sleeve-seal system.
   4. Concrete Slabs Above Grade:
      a. Piping Smaller Than NPS 6: Galvanized Steel pipe sleeves.
      b. Piping NPS 6 and Larger: Galvanized Steel pipe sleeves.

3.04 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

3.05 CUTTING AND OPENINGS

A. Comply with Division 01 “Cutting and Patching”.

HMC Architects
3.06 EQUIPMENT INSTALLATION

A. Install equipment to minimize pressure drop and allow adequate access headroom unless specific mounting heights are indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated in drawings (note that in some cases non-parallel installation is indicated in the drawing to reduce pressure drop).

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.07 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer’s written instructions and according to seismic codes at Project.
   1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.
   7. Use 3000-psi, 145 PCF, 56-day compressive-strength concrete and reinforcement as specified in Division 03 Section “Cast-in-Place Concrete.”

3.08 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.09 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.
B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION
SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer’s factory or shipped separately by equipment manufacturer for field installation.
   B. Insert Editor’s Note Here
   C. Related Sections include the following:
      1. Section 23 05 14 “Variable-Frequency Drives for HVAC Equipment”.
      2. Section 23 21 23 “Hydronic Pumps”.
      3. Section 23 34 00 “HVAC Fans”.

1.03 COORDINATION
   A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
      1. Motor controllers.
      2. Torque, speed, and horsepower requirements of the load.
      3. Ratings and characteristics of supply circuit and required control sequence.
      4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS
   A. Comply with NEMA MG 1 unless otherwise indicated.
   B. Duty: Continuous duty at ambient temperature of 104 deg F (40 C) and at altitude of 3300 feet (1000 m) above sea level.
   C. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
   D. Motors for submersible pumps shall be hermetically sealed.
E. Motors 3/4 HP (560 W) 3/4 HP or greater shall be polyphase unless otherwise indicated.

F. Minimum Motor Service Factor: 1.15.

2.02 MOTOR ENCLOSURES

A. Totally Enclosed, Fan Cooled (TEFC) for motors located outdoors, or in unconditioned or unventilated indoors areas, or in air streams unless otherwise indicated.

B. Open Dripproof (ODP) for other cases unless otherwise indicated.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficiency, as defined in NEMA MG 1.

C. Polyphase motors shall be suitable for use with Variable-frequency Drives.

D. Construction:
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes to 1600 volts, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
   3. Provide motor shaft grounding ring.
   5. Bearings: Regreaseable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. Multispeed Motors: Separate winding for each speed.

F. Wiring Terminations:
   1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.04 SINGLE-PHASE MOTORS

A. Single-phase motors larger than 1/20 HP (37.5 W) shall be Electronically Commutated (ECM) unless not offered by the manufacturer.

B. Electronically Commutated Motors (ECM)
   1. Motor shall be brushless DC type specifically designed for HVAC applications with heavy duty ball bearings and Electronic Commutation. It shall contain internal circuitry that converts single phase power into a DC signal. Speed control is achieved through a 0-10 volt DC control signal input through the pre-wired controls wires.
2. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.

C. Non-ECM
1. Motors shall be one of the following, to suit starting torque and requirements of specific motor application (listed in order of preference):
   a. Permanent-split capacitor.
   b. Capacitor start, capacitor run.
   c. Capacitor start, inductor run.
   d. Split phase.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Motors 1/20 HP (37.5 W) and Smaller: Shaded-pole type.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION
SECTION 23 05 14

VARIABLE FREQUENCY DRIVES FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes solid-state, PWM, Variable Frequency Drives for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections:
   1. Section 23 05 13 “Common Motor Requirements for HVAC Equipment”.
   2. Division 26 for monitoring and control of motor circuits.

1.03 DEFINITIONS

A. ASD: Adjustable Speed Drive.

B. BAS: Building automation system.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. PWM: Pulse-width modulated.

K. RFI: Radio-frequency interference.

L. VFC: Variable frequency controller.

M. VFD: Variable frequency drive.
1.04 ACTION SUBMITTALS

A. See Division 01 and Section 23 05 00 “HVAC General Requirements” for submittal procedures. Also may be submitted as Variable-Frequency Controller (VFC), Adjustable Speed Drive (ASD), or similar.

B. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Include short circuit interrupting capacities in compliance with Division 26.
   4. Include electrical power monitoring information in compliance with Division 26.

C. Shop Drawings: For each VFD indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Include certification that VFD selection has been coordinated with equipment being served.
   5. Include ventilation means, points of connection, and air path.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For each VFD, accessories, and components, from manufacturer.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

D. Product Certificates: For each VFD from manufacturer.


F. Source quality-control reports.
G. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Division 01 “Operation and Maintenance Data,” include the following:
      a. Manufacturer’s written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
      b. Manufacturer’s written instructions for testing, adjusting, and reprogramming microprocessor control modules.
      c. Manufacturer’s written instructions for setting field-adjustable timers, controls, and status and alarm points.
      d. Routine maintenance requirements for VFDs and all installed components.
      e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
      f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Indicating Lights: Two of each type and color installed.
   4. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.08 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFDs covered and protected, in shipping splits of lengths that can be moved past obstructions in delivery path.

B. Store VFDs indoors on dunnage in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Ambient Temperature: 0 deg F to 104 deg F.
   2. Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 1000 feet.

1.11 COORDINATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, control circuits, required control sequence, and duty cycle of motor and load.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:
   1. ABB Low Voltage Drives.
   2. Cerus Industrial, Inc.
   3. Danfoss Inc.
   4. Eaton.
   5. Emerson Industrial Automation.
   7. Rockwell Automation, Inc.
   8. Schneider Electric USA, Inc.
10. Yaskawa Electric America, Inc.

2.02 VARIABLE FREQUENCY DRIVES

A. Description: Variable-frequency motor drive / controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. IGBT, PWM; NEMA ICS 2, UL 508A listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design A and B, premium efficiency 3-phase induction motor by adjusting output voltage and frequency.
   2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

B. Application: Variable torque.

C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

D. Output Rating:
   1. Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:
   1. Input AC Voltage Tolerance of 380 to 500 V, plus or minus 15 percent.
   2. Input AC Voltage Unbalance: Not exceeding 3 percent.
   3. Input Frequency Tolerance of 50/60 Hz, plus or minus 3 percent.
   4. Minimum Efficiency: 97 percent at 60 Hz, full load.
   7. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   8. Starting Torque: 100 percent of rated torque or as indicated.
   9. Speed Regulation: Plus or minus 5 percent.
   10. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

F. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

G. Isolated control interface to allow controller to follow control signal over a 40:1 speed range.
   1. Electrical Signal: 4 to 20 mA at 24 V.

H. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.
   5. Current Limit: 30 to a minimum of 150 percent of maximum rating.
I. Self-Protection and Reliability Features:
   1. Input transient protection by means of surge suppressors.
   2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
   4. Critical frequency rejection, with three selectable, adjustable deadbands.
   7. Instantaneous line-to-line and line-to-ground overcurrent trips.
   10. Short-circuit protection.
   11. Motor overtemperature fault.

J. Multiple-Motor Capability: Drive suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

K. Automatic Reset/Rerstart: Attempts three restarts after fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to drive, motor, or load.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
   1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.

2.03 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
   3. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

C. Historical Logging Information and Displays:
   1. Real-time clock with current time and date.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in drive door and connected to indicate the following parameters:
   1. Output frequency (Hz).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (VDC).
   9. Set-point frequency (Hz).
   10. Motor output voltage (V).

E. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
   3. Output Signal Interface:
      a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
         1) Output frequency (Hz).
         2) Output current (load).
         3) DC-link voltage (VDC).
         4) Motor torque (percent).
         5) Motor speed (rpm).
         6) Set-point frequency (Hz).
         7) Instantaneous power consumption
4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

G. Communications: Provide an RS485 interface allowing VFD to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFD to be programmed via BMS control. Provide capability for VFD to retain these settings within the nonvolatile memory.

2.04 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer’s harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

2.05 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   4. Other Wet or Damp Indoor Locations: Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as “Plenum Rated.”

2.06 ACCESSORIES

A. Devices shall be factory installed in enclosure, unless otherwise indicated.


C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
E. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

F. Supplemental Digital Meters:
   1. Elapsed-time meter.
   2. Kilowatt meter.

G. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

I. Cooling Fan and Exhaust System: For NEMA 250; UL 508 component recognized: Supply fan, with intake and exhaust grills and filters.

J. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

K. Spare control-wiring terminal blocks; wired.

2.07 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to requirements in NEMA ICS 61800-2.
   1. Test each VFD while connected to its specified motor.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

C. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.02 APPLICATIONS
A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.
B. Select horsepower rating of controllers to suit motor controlled.

3.03 INSTALLATION
A. VFDs to be mounted by Mechanical Contractor and connected by the Electrical Contractor unless noted otherwise. Electrical Contractor to confirm need for disconnect switch in addition to VFD and provide if necessary.
B. Wall-Mounting: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.
C. Free Standing: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to Unistrut or similar support system.
D. Comply with mounting and anchoring requirements specified in Division 26.
E. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

3.04 IDENTIFICATION
A. Identify VFDs, components, and control wiring according to Section 23 05 53 “Identification for HVAC Piping and Equipment.”

3.05 CONTROL WIRING INSTALLATION
A. Install wiring between VFDs and remote devices and facility’s central-control system. Comply with requirements in Division 26.
B. Bundle, train, and support wiring in enclosures.
C. Connect selector switches and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.06 CONNECTIONS
A. Conduit installation requirements are specified in Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.
B. Ground equipment according to Division 26.

3.07 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
   5. Test each motor for proper phase rotation.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
   9. VFDs will be considered defective if they do not pass tests and inspections.
  10. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.08 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer’s written instructions.

3.09 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set the taps on reduced-voltage autotransformer controllers.

C. Set field-adjustable circuit-breaker trip ranges.
D. Set field-adjustable pressure switches.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION
SECTION 23 05 16
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Flexible-hose seismic expansion joints.
   2. Alignment guides and anchors.
   3. Pipe loops and swing connections.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the registered structural or civil engineer (registered in the state the project is located) responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer’s number, size, material, pressure rating, end connections, and location for each expansion joint.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.05 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code – Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.02 SEISMIC EXPANSION JOINTS

A. Flexible-Hose Seismic Expansion Joints:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex Pression Ltd.
      b. Flexicraft Industries.
      c. Mason Industries, Inc.
      d. Metraflex Company (The).
   2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
   3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
   4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with threaded-joint end connections.
      a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
      a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.
   8. Accessories:
      a. Seismic breakaway coupling, with disengagement rating of 140 percent of static supported weight.
      b. Tether cable.

2.03 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advanced Thermal Systems, Inc.
      b. Flex-Hose Co., Inc.
c. Hyspan Precision Products, Inc.
d. Mason Industries, Inc.
e. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider forbolting to pipe.

B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

PART 3 - EXECUTION

3.01 EXPANSION JOINT INSTALLATION
   A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.02 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION
   A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

   B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

   C. Attach guides to pipe, and secure guides to building structure.

   D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

   E. Anchor Attachments:
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer’s written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION
SECTION 23 05 19

METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pressure gauges and pressure gauge taps.
   2. Thermometers
   3. Thermometer wells (thermowells).
   4. Test plugs and test plug kits.
   5. Static pressure air gauges.

B. Related Sections:
   1. Section 23 21 13 “Hydronic Piping”.

1.03 REFERENCE STANDARDS

A. ASME B40.100 – Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2013.


1.04 ACTION SUBMITTALS

A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.

B. Product Data: Provide table that indicates use, operating range, total range and location for manufactured components.

C. Project Record Documents: Record actual locations of components and instrumentation.

1.05 INFORMATIONAL SUBMITTALS

A. Product Certificates: for each type of gauge, thermowell, test plug, and test plug kit from manufacturer.
1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: for each type of gauge, thermowell, test plug, and test plug kit to include in operation and maintenance manuals.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Temperature and Pressure Gauges: one of each type, range, and size.

1.08 FIELD CONDITIONS

A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.01 PRESSURE GAUGES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Dwyer Instruments, Inc.
   2. Moeller Instrument Co., Inc.
   3. Omega Engineering, Inc.

B. Direct-Mounted, Dial-Type Pressure Gauges: ASME B40.100, UL 393 drawn steel or cast aluminum case, phosphor bronze bourdon tube, brass or stainless pressure connection with NPS 1/2 threads, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
   1. Dial: Black scale on white background with etched scale markings graduated in psi (kPa).
   2. Size: 4-1/2 inch diameter.
   3. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
   4. Provide dedicated isolation valve for each insertion well.

C. Pressure gauge tappings:
   1. Gauge Cock: Tee or lever handle, brass or stainless steel, NPS 1/2 connection for maximum 150 psig.
   2. Needle Valve: Brass or stainless steel, NPS 1/2 connection for minimum 150 psig.
   3. Pulsation Damper: Pressure snubber, brass, ASME B40.100, NPS 1/2 connection, include extensions for use on insulated piping where required.

2.02 THERMOMETERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Dwyer Instruments, Inc.
   2. Omega Engineering, Inc.
   3. Weksler Glass Thermometer Corp.
B. Stem-Type Thermometers – Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
   1. Size: 9 inch scale with scale markings graduated in deg F (deg C).
   2. Window: Clear Lexan.
   4. Accuracy: 2 percent of full range, per ASTM E77.

C. Dial-Type Thermometers: Adjustable angle: ASME B40.200, stainless steel case, with front recalibration, bimetallic with fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
   1. Size: 5 inch diameter with scale markings graduated in deg F (deg C).
   2. Lens: Clear glass.
   3. Accuracy: 1 percent of full range.

D. Thermometer Supports:
   1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
   2. Flange: 3 inch (75-mm) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.03 THERMOWELLS

A. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   2. Type: Stepped shank unless straight or tapered shank is indicated.
   4. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
   5. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
   6. Bore: Diameter required to match thermometer bulb or stem.
   7. Insertion Length: Length required to match thermometer bulb or stem.
   8. Lagging Extension: Include on thermowells for insulated piping and tubing.
   9. Bushings: For converting size of thermowell’s internal screw thread to size of thermometer connection.
   10. Strength: Thermowell shall be designed for a minimum of 35 FPS fluid velocity.

2.04 TEST PLUGS AND TEST PLUG KITS

A. Test Plugs: NPS 1/4 or NPS 1/2 brass or stainless fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene or EPDM core for 500 psig pressure rating at 200 deg F. Include extended stem where installed on insulated piping.

B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gauges, one gauge adapters with 1/8 inch probes, two 1 inch dial thermometers.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

C. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.

D. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Extend nipples and siphons to allow clearance from insulation.

E. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch (64 mm) for installation of thermometer sockets as necessary. Ensure sockets allow clearance from insulation.

F. Install thermometers in air duct systems on flanges.

G. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets. Where thermometers are provided on local panels, duct or pipe mounted thermometers are provided on local panels, duct or pipe mounted thermometers are not required.

H. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes. Ensure thermowells allow clearance from insulation.

I. Fill thermowells with heat-transfer medium.

J. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

K. Coil and conceal excess capillary on remote element instruments.

L. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

M. Locate test plugs adjacent to thermometers and thermometer sockets. Install test plugs in piping tees.

3.02 ADJUSTING

A. After installation, calibrate meters and gauges according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.
3.03 GAUGE SCHEDULE

A. Unless noted otherwise, provide each gauge so that its range exceeds the full operating range of the system it is associated with by 1.5 to 2 times and so that the expected minimum and maximum operating points are within the gauge range.

END OF SECTION
SECTION 23 05 23
VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.
B. Related Sections:
   1. Section 23 05 53 “Identification for HVAC Piping and Equipment”.
   2. Section 23 21 13 “Hydronic Piping”.

1.03 DEFINITIONS
A. CWP: Cold working pressure.
B. EPDM: Ethylene propylene-diene terpolymer rubber.
C. PTFE: Polytetrafluoroethylene

1.04 ACTION SUBMITTALS
A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.
B. Product Data: For each type of valve.
   1. Certification that products that come into contact with potable water comply with NSF 61 Annex G and NSF 372.

1.05 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: for each type of valve to include in operation and maintenance manuals.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, soldered ends, and grooves.
   4. Set butterfly valves closed or slightly open.
B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature.
      If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. Valves shall be manufactured in the United States.

C. Coordinate joint connection with Valve schedule in Part 3 and piping system specifications.
   1. ASME Compliance:
   2. ASME B1.20.1 for threaded end valves.
   3. ASME B16.1 for flanges on iron valves.
   4. ASME B16.5 for flanges on steel valves.
   5. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   7. ASME B31.9 for building service piping valves.

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.


F. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

G. Valve Actuator Types:
   1. Gear Actuator: For valves NPS 8 and larger.

H. Valves in Insulated Piping: With 2-inchstem extensions; operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

I. All plumbing components including but not limited to valves and other wetted parts shall be lead free.
2.02 BALL VALVES

A. Two-Piece, Bronze Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Two-Piece bronze body, chrome-plated brass ball, bronze trim, PTFE seat, steel handle with plated plastisol coating, 600 psig CWP rating.

B. Steel Ball Valves with Full Port:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Hammond Valve.
      c. Milwaukee Valve Company.
   2. Description: Carbon steel (ASTM A216) split body, stainless steel ball and stem, PTFE seat.

2.03 BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO INC.
      b. Conbraco Industries, Inc.
      c. Hammond Valve.
      d. Milwaukee Valve Company.
      e. DeZURIK.
   2. Description: Cast iron (ASTM A126) or ductile iron (ASTM A536) lug type body, suitable for bidirectional dead-end service at rated pressure without use of downstream flange, EPDM seat, one or two piece stainless steel stem, nickel-plated ductile iron disc.
   3. Standard: MSS SP-67, Type I.

B. Iron, Grooved-End Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
      b. Kennedy Valve Company; a division of McWane, Inc.
      c. Tyco Fire Products LP.
   2. Description: Coated ductile iron body, EPDM seal, two-piece stainless steel stem, coated ductile iron disc.
   3. Standard: MSS SP-67, Type I.
2.04 CHECK VALVES

A. Bronze, Swing Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
2. Description: Bronze (ASTM B62) body, spring loaded, bronze disc.

B. Iron Swing Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane.
   b. NIBCO INC.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
2. Description: Gray iron (ASTM A126) body with bolted bonnet, clear or full waterway, spring-loaded, asbestos free gasket, bronze trim, PTFE disc.
3. Standard: MSS SP-71, Type I.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves.

3.02 INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.
E. Install valve tags. Comply with requirements in Section 23 05 53 “Identification for HVAC Piping and Equipment” for valve tags and schedules.

3.03 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.04 VALVE SCHEDULE

A. Refer to piping system sections for valve schedules.

B. Coordinate Class or CWP rating with associated piping system rating.
   1. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

END OF SECTION
SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section Includes:
      1. Metal pipe hangers and supports.
      2. Trapeze pipe hangers.
      3. Metal framing systems.
      4. Thermal-hanger shield inserts.
      5. Fastener systems.
      6. Equipment supports.

   B. Related Requirements:
      1. Division 05 for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
      2. Section 23 00 00 “HVAC General Requirements” for grout.
      3. Section 23 05 16 “Expansion Fittings and Loops for HVAC Piping” for pipe guides and anchors.
      4. Section 23 05 48 “Vibration and Seismic Controls for HVAC” for vibration isolation devices.
      5. Section 23 31 13 “Metal Ducts” for duct hangers and supports.

1.03 DEFINITIONS
   A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.04 PERFORMANCE REQUIREMENTS
   A. Delegated Design: Design pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer registered in State of California, using performance requirements and design criteria indicated.

   B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, including comprehensive engineering analysis by a qualified professional engineer registered in State of California, using performance requirements and design criteria indicated.
      1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design supports for shared rack supported system including multiple system pipes, capable of supporting combined weight of rack supported system, system contents and components.
3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
4. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.05 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Pipe stands.
   4. Equipment supports.

1.06 INFORMATIONAL SUBMITTALS
A. Welding certificates.

1.07 QUALITY ASSURANCE

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS
A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: Type 304 Stainless Steel, MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

2.02 TRAPEZE PIPE HANGERS
A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 METAL FRAMING SYSTEMS
A. Metal Framing Systems:
1. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

2.04 THERMAL-HANGER SHIELD INSERTS
A. Manufacturers:
1. Pipe Shields Inc.
B. Insulation-Insert Material for Heat Trace Piping: Water-repellent treated, ASTM C533, Type I calcium silicate with 100-psig minimum compressive strength.
C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
D. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.05 FASTENER SYSTEMS
A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.06 EQUIPMENT SUPPORTS
A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.07 MISCELLANEOUS MATERIALS
A. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer’s written instructions.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
M. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
   6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.02 EQUIPMENT supports

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

A. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.
3.04 ADJUSTING
A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.05 PAINTING
A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09.
C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.06 HANGER AND SUPPORT SCHEDULE
A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
F. Use stainless-steel pipe hangers and supports for underground piping.
G. Use thermal-hanger shield inserts for insulated piping and tubing.
H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
4. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
11. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
13. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
14. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
15. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
16. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
17. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
18. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
19. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
20. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
2. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
3. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
4. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
5. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
6. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
7. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
8. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

9. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.

10. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

M. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

O. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION
SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Isolation pads.
   2. Isolation mounts.
   3. Restrained elastomeric isolation mounts.
   4. Freestanding and restrained spring isolators.
   5. Housed spring mounts.
   6. Elastomeric hangers.
   7. Spring hangers.
   8. Spring hangers with vertical-limit stops.
   9. Pipe riser resilient supports.
  10. Resilient pipe guides.
  11. Seismic snubbers.
  12. Restraining braces and cables.
  13. Steel and inertia, vibration isolation equipment bases.

B. Related Sections:
   1. Section 23 21 13 “Hydronic Piping”.

1.03 REFERENCE STANDARDS


1.04 ACTION SUBMITTALS

A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.
B. Product Data: Provide schedule of vibration isolator type with location, rated load, rated deflection, load/deflection curve, and overload capacity for each isolation device. Submit catalog information indicating materials, acoustical performance (if applicable), and dimensional data. Denote exact model number that is to be used cross referenced against equipment tag.

C. For equipment that is contractor supplied or is substituted for those that are specified, provide structural calculations for equipment anchorage to the structure, sealed and signed by a civil engineer registered in the State of California, demonstrating conformance with section 13.6 of ASCE 7-05 (American Society of Civil Engineers) “Minimum Design Loads of Buildings and Other Structures”.

D. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each. Indicate seismic control measures. Signed and sealed by a qualified professional structural engineer. Include the following:
   1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. Indicate location and type of vibration isolation with static and dynamic loads on each.
   2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base size and weight, equipment static loads, power transmission, component misalignment, and cantilever loads.
   4. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
   5. Details for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.

E. Manufacturer’s Instructions: Indicate installation instructions with special procedures and setting dimensions.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Welding certificates.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: for each device to include in operation and maintenance manuals.

B. Project Record Documents: Record actual locations of equipment and vibration isolation treatments defined in this section. Record actual locations of hangers including attachment points, loads and static deflection at time of building handover.
1.07 MAINTENANCE MATERIAL SUBMITTALS
A. Extra Temperature and Pressure Gauges: one of each type, range, and size.

1.08 QUALITY ASSURANCE
A. Perform design and installation in accordance with applicable codes.
B. Designer Qualifications: Perform design under direct supervision of a Professional Engineer experienced in design of this type of work and registered and licensed in the State in which the Project is located.
C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.
D. Installer Qualifications: Company specializing in performing Work of this section with not less than three years of documented experience.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
A. Kinetics Noise Control, Inc.
B. Mason Industries.
C. Vibration Mountings & Controls, Inc.

2.02 PERFORMANCE REQUIREMENTS
A. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.
B. Steel springs shall function without undue stress or overloading.
C. All equipment mounted on vibration isolated bases to have minimum operating clearance of 2 inches between the base and floor or support beneath unless noted otherwise.

2.03 EQUIPMENT SUPPORT BASES
A. Structural Bases [SB]:
   1. Construction: Engineered, structural steel frames with welded brackets for side mounting of the isolators.
   2. Frames: Square, rectangular or T-shaped.
   3. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.

5036004 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
D-4014 Diablo Valley College P/K Complex 23 05 48 - 3
B. Concrete Inertia Bases [CIB]:
   1. Mass: Minimum of 1.5 times weight of isolated equipment.
   2. Construction: Structured steel channel perimeter frame, with gusset brackets and anchor bolts, adequately reinforced, concrete filled.
   3. Connecting Point: Reinforced to connect isolators and snubbers to base.
   4. Concrete: Reinforced 3,000 psi (20 MPa) concrete.
   5. Bases for pumps shall be large enough to provide support for suction and discharge elbows.
   6. The base depth shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6 inches. The base depth need not exceed 12 inches unless specifically recommended by the base manufacturer for mass or rigidity.
   7. Forms shall include minimum concrete reinforcement consisting of half-inch bars or angles welded in place on 6 inch centers running both ways in a layer 1-1/2 inches above the bottom, or additional steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations.
   8. Height saving brackets shall be employed in all mounting locations to maintain a minimum 2 inch clearance below the base.
   9. Basis of design: Mason “K”.

2.04 VIBRATION ISOLATORS

A. Neoprene Pad Isolators [NP]:
   1. Rubber or neoprene-waffle pads.
   2. Durometer to achieve static deflection as specified.
   3. Minimum 1/2 inch thick.
   4. Maximum loading 40 psi
   5. Height of ribs: not to exceed 0.7 times width.
   6. Configuration: 1/2 inch thick waffle pads bonded each side of 1/4 inch (6 mm) thick steel plate.
   7. Basis of design: Mason “WM”.

B. Open Free-Standing Spring Isolators [FS]:
   1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   2. Color code springs for load carrying capacity.
   3. Springs: Minimum horizontal stiffness equal to 100 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
   4. Free standing and laterally stable spring isolators (single or multiple steel springs) without any housing and complete with 1/4 inch neoprene acoustical pads between the base plate and the support.
   5. Spring diameter shall be no less than 0.8 of the compressed height of the spring at design load.
   6. Spring Mounts: Furnish with leveling devices, minimum 0.25 inch thick neoprene sound pads, and zinc chromate plated hardware.
   7. Sound Pads: Size for minimum deflection of 0.05 inch; meet requirements for neoprene pad isolators.
   8. Provide all mountings with leveling bolts, rigidly bolted to the equipment.
   9. Provide height saving mounting brackets where applicable, height adjustment bolts.
   10. Basis of design: Mason “SLF”.
C. Restrained Spring Isolators [RS]:
   1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   2. Color code springs for load carrying capacity.
   3. Springs: As in type FS.
   4. Spring Mounts: As in type FS.
   5. Sound Pads: As in type FS.
   6. Restraint: Furnish mounting frame and limit stops. A minimum 1/2 inch clearance shall be maintained around the restraint bolts, housings, and springs so as not to interfere with the spring action.
   7. Basis of design: Mason “SLR”.

D. Riser Clamp Pad [RP]:
   1. Resilient pad between riser clamp and support structure to eliminate rigid contact.
   2. Basis of Design: Regufoam, Armaflex or approved equivalent.

E. Spring Hanger [SH]
   1. For Exterior and Humid Areas: Furnish hot dipped galvanized housings and neoprene coated springs.
   2. Color code springs for load carrying capacity.
   5. Misalignment: Capable of 30 degree arc before contacting hanger housing.
   6. Basis of design: Mason “30N”.

F. Neoprene Hangers [NH]:
   1. Molded neoprene units in a steel hanger frame.
   2. Double deflection types with static deflection range from 0.3 to 0.5 inch.
   3. Designed to preclude contact of hanger rods with frame (30 degrees misalignment). Insert neoprene bushing where rod passes through housing.
   4. Basis of design: Mason “HD”.

G. Thrust Restraints:
   1. Thrust restraint shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be preset at the factory for thrust and be adjusted in the field to allow for a maximum of 1/4 inch movement during starting or stopping of the equipment.
   2. The assembly shall be furnished complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.
   3. Thrust restraints shall be provided for all equipment as follows:

<table>
<thead>
<tr>
<th>Spring Isolator Deflection</th>
<th>Thrust</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inches or more</td>
<td>Greater than 5% of equipment weight</td>
</tr>
<tr>
<td>2 inches</td>
<td>Greater than 10% of equipment weight</td>
</tr>
<tr>
<td>1 inch</td>
<td>Greater than 15% of equipment weight</td>
</tr>
</tbody>
</table>

Note: Equipment weight includes all isolated items including vibration isolation base.
4. Height saving brackets shall be employed in all mounting locations to maintain a minimum 2 inch clearance below the base.
5. Basis of design: Mason "WB".

2.05 SEISMIC SNUBBER ASSEMBLIES

A. Comply with:
   1. ASHRAE Handbook – HVAC Applications
   2. SMACNA – Seismic Duct Restraint Manual

B. All Directional External:
   1. Application: Minimum three (3) snubbers are required for each equipment installation, oriented properly to restrain isolated equipment in all directions.
   2. Construction: Interlocking steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
   3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
   4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

C. Lateral External:
   1. Application: Minimum three (3) snubbers are required for each stable equipment installation, oriented properly to restrain isolated equipment in all lateral directions where uplift forces are zero or addressed by other restraints.
   2. Construction: Steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
   3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
   4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

2.06 SEISMIC RESTRAINTS FOR SUSPENDED COMPONENTS AND EQUIPMENT

A. Comply with:
   1. ASHRAE Handbook – HVAC Applications
   2. SMACNA – Seismic Duct Restraint Manual

B. Cable Restraints:
   1. Wire Rope: Steel wire strand cables sized to resist seismic loads in all lateral directions.
   3. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
   4. Connections:
   5. Use overlapping wire rope U clips, cable clamping bolts, swaged sleeves or seismically rated tool-less wedge insert lock connectors.
   6. Internally brace clevis hanger bracket cross bolt to prevent deformation.
7. Vertical Suspension Rods: Attach required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

C. Rigid Restraints:
1. Structural Element: Sized to resist seismic loads in all lateral directions and carry both compressive and tensile loading.
2. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
3. Connections: Internally brace clevis hanger bracket cross bolt to prevent deformation.
4. Static Support System: Anchorage capable of carrying additional tension loads generated by the vertical component of the rigid brace compression which is additive to any static load requirements on the system.
5. Vertical Suspension Rods: Attached required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

2.07 ACCESSORIES

A. Flexible pipe connectors:
1. Manufacturers:
   a. Metraflex.
   b. Keflex.
   c. Mason.
2. Steel Piping:
   a. Inner Hose: Carbon Steel
   c. Pressure Rating: 125 psig WSP and 450 deg F.
   d. Joint: Flanged.
   e. Size: Match pipe size.
   f. Maximum offset: 1 inch on each side of installed centerline.
3. Copper Piping:
   a. Inner Hose: Bronze
   b. Exterior Sleeve: Braided bronze.
   c. Pressure Rating: 125 psig WSP and 450 deg F.
   d. Joint: Threaded with brass fittings.
   e. Size: Match pipe size.
   f. Maximum offset: 1 inch on each side of installed center line.
4. Pipework flexible connections shall be manufactured of multiple plies of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. 1-1/2 in. Straight connectors shall have two spheres. Connectors up to and including 1-1/2 in. diameter may have threaded ends. Connectors 2 in. and larger shall be manufactured with floating galvanized flanges recessed to lock the connector’s raised face neoprene flanges.
5. Hoses shall be installed on the equipment side of the shut valves.
6. Basis of Design: Elbows shall be Mason-Flex “MFNEC”, straight connectors shall be Mason-Flex “MFTFU” or “MFTNC”, and control cable assemblies Mason “ACC”.

VIBRATION AND SEISMIC CONTROLS FOR HVAC
PIPING AND EQUIPMENT
D-4014 Diablo Valley College P/K Complex 23 05 48 - 7
PART 3 - EXECUTION

3.01 INSTALLATION – GENERAL

A. Install in accordance with manufacturer’s instructions.

B. Adjust equipment level.

C. Install spring hangers without binding.

D. Provide a minimum of 1” clearance between the building structure (walls, floors, and ceilings) and vibration isolated supports, ducts, pipes, and equipment.

E. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

F. Provide pairs of thrust restraint horizontal limit springs on fans based on static pressure as scheduled.

G. Do not use vibration isolation components to straighten or connect misaligned sections of piping or ductwork.

H. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

I. The installation or use of vibration isolators must not cause any change in position of equipment, piping, or ducts that result in stresses in any connections or misalignment of shafts or bearings. Equipment shall be maintained in a rigid position during installation. The load shall not be transferred to the isolators until the installation is complete and in operational condition.

J. Do not install any mechanical equipment, ducts, or piping that makes rigid contact with the “building” unless it is approved in this specification or by the Engineer. “Building” includes, but is not limited to, slabs, beams, columns, walls, partitions, ceilings, studs, ceiling framing, and suspension systems. Resiliently-isolated piping shall not contact building construction or other equipment or items.

K. Align isolation hanger rods to clear the hanger box under all operating conditions.

L. Level vibration isolated equipment under rated design operating conditions while maintaining the isolation criteria. Isolators shall be plumb and aligned to preclude misalignment or undesired contact during operation.

3.02 INSTALLATION – SEISMIC

A. Seismic Snubbers:
   1. Provide on all isolated equipment, piping and ductwork.
   2. Provide minimum of four seismic snubbers located close to isolators.
   3. Snub equipment designated for post-disaster use to 0.05 inch maximum clearance.
4. Snub all other equipment between 0.15 inch and 0.25 inch clearance.

B. Floor and Base-Mounted Equipment, Vibration Isolated Equipment and associated Vibration and Seismic Controls for Connections:
   1. Install equipment anchorage items designed to resist seismic design force in any direction.
   2. Install vibration and seismic controls designed to include base and isolator requirements.
   3. Provide flexible connections between equipment and interconnected piping.
   4. Provide isolators and restraints designed for amplified code forces per ASCE 7 and with demonstrated ability to resist required forces including gravity, operational and seismic forces.

C. Suspended Mechanical Equipment:
   1. Provide supports and bracing to resist seismic design force in any direction.
   2. Provide flexible connections between equipment and interconnected piping.
   3. Brace equipment hung from spring mounts using cable or other bracing that will not transmit vibration to the structure.
   4. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

D. Wall mounted Mechanical Equipment:
   1. Provide support and bracing to resist seismic design force in any direction.
   2. Install backing plates or blocking as required to deliver load to primary wall framing members.
   3. Anchoring to gypsum wallboard, plaster or other wall finish that has not been engineered to resist imposed loads is not permitted.

E. Piping:
   1. Provide seismic bracing in accordance ASC 7.
   2. Provide supports, braces, and anchors to resist gravity and seismic design forces.
   3. Provide flexible connections between floor-mounted equipment and suspended piping; between unbraced piping and restrained suspended items; as required for thermal movement; at building separations and seismic joints; and wherever relative differential movements could damage pipe in an earthquake.
   4. Brace resiliently supported pipe with cable bracing or alternate means designed to prevent transmission of vibrations and noise to the structure.
   5. Brace every run 5.0 feet or more in length with two transverse and one longitudinal bracing locations.
   6. Pipes and Connections Constructed of Ductile Materials (copper, ductile iron, steel or aluminum and brazed, welded or screwed connections):
      a. Provide transverse bracing at spacing not more than 40.0 feet on center.
      b. Provide longitudinal bracing at spacing not more than 80.0 feet on center.
   7. Pipes and Connections Constructed of Non Ductile Materials (cast iron, no-hub, plastic or non-UL Listed grooved coupling pipe):
      a. Provide transverse bracing at spacing not more than 20.0 feet on center.
      b. Provide longitudinal bracing at spacing not more than 40.0 feet on center.
      c. Provide lateral restraint for risers at not more than 30 feet on center or as required for horizontal runs, whichever is less.
8. Piping Explicitly Exempt from Seismic Bracing Requirements:
   a. Provide flexible connections between piping and connected equipment, including in-line devices such as VAV boxes and reheat coils.
   b. Install piping consistent with ASCE 7, such that swinging of the pipes will not cause damaging impact with adjacent components, finishes, or structural framing while maintaining clear horizontal distance of 67 percent of the hanger length between subject components.
   c. Provide swing restraints as required to control potential impact due to limited space between subject components.

9. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

F. Ductwork:
   1. Provide seismic bracing for ducts with cross sectional area greater than 6 sq ft (independent of duct contents).
   2. Provide seismic bracing for all ducts containing hazardous materials.
   3. Provide supports, braces, and anchors to resist gravity and seismic design forces.
   4. Independently support in-line devices weighing more than 20 pounds.
   5. Independently support and brace all in-line devices weighing more than 75 pounds.
   6. Provide unbraced piping attached to braced in-line equipment with adequate flexibility to accommodate differential displacements.
   7. Positively attach dampers, louvers, diffusers and similar appurtenances to ductwork with mechanical fasteners.
   8. Install duct supports designed to resist not less than 150 percent of the duct weight.
   9. The use of power driven fasteners is prohibited in the hanging of ducts weighing over 10 pounds per lineal foot for seismic design categories D, E, and F.
   10. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an IAS AC172 accredited inspection body or otherwise accepted by applicable codes is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

G. Tanks:
   1. Install tank anchorage, tank legs and/or supporting structure designed to resist design force.
   2. Provide flexible connections between tank and interconnected piping.

3.03 INSTALLATION – VIBRATION ISOLATING EQUIPMENT

A. Flexible Pipe Connections:
   1. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
   2. Use flexible double sphere neoprene pipe connectors for connections to pumps on vibration isolators.
   3. Use flexible wire braided connectors on branch connections to heat transfer equipment.
4. Install flexible connectors to accommodate displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

B. Pipe and Duct Supports:
1. Isolate all pipes & ducts attached to the inlet and discharge of spring-isolated equipment and pressure-reducing valves using the same isolator type and static deflection as the equipment isolators within the mechanical room or 50 feet (whichever is greater) from the inlet and discharge.
2. Isolate the remainder of horizontal pipe runs 2-inches in diameter and greater using Type NM or NH isolators.
3. All vertical risers for piping 2-inches diameter or greater shall be isolated from the building structure by means of guides, supports, and spring isolators. The support systems shall be an engineered solution taking into account pipe movement, expansion and vibration isolation.
4. All vertical risers for piping less than 2-inches diameter shall be isolated from the building structure by Type NM neoprene mount below flanges or pipe clamps. Where fixing to structure is required, neoprene isolator bushings shall be used to provide resilient support.

C. Bases:
1. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.
2. Set steel bases for 1 inch clearance between housekeeping pad and base.
3. Set concrete inertia bases for 2 inch clearance between housekeeping pad and base.

D. Install isolation for motor driven equipment.

3.04 FIELD QUALITY CONTROL

A. Inspect isolated equipment after installation and submit report. Include static deflections.

B. Inspect isolator seismic-restraint clearance.

C. Test isolator deflection.

D. Inspect minimum snubber clearances.

3.05 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

3.06 SCHEDULE

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Isolator Type</th>
<th>Minimum Static Deflection (in)</th>
<th>Bases</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air handling unit fans (internal isolation)</td>
<td>FS</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air handling units – suspended (external isolation)</td>
<td>NH</td>
<td>1/8</td>
<td></td>
<td>Provided by unit manufacturer</td>
</tr>
<tr>
<td>Centrifugal fans – base mounted</td>
<td>FS</td>
<td>1</td>
<td>SB</td>
<td></td>
</tr>
<tr>
<td>Fan coil units and other ducted rotating small equipment – floor mounted</td>
<td>FS</td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan coil units and other ducted rotating small equipment – suspended</td>
<td>SH</td>
<td>3/4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Valve tags.
   6. Warning tags.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Kolbi Pipe Marker Co.
      c. Seton Identification Products.
   2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   4. Background Color: Black.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.


B. Plastic Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Kolbi Pipe Marker Co.
   c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
4. Background Color: Black.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

C. Label Content: Include equipment’s Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Marking Services Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.


I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Label Content: Include caution and warning information plus emergency notification instructions.

2.03 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping and at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.04 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

C. Maximum Temperature: Able to withstand temperatures up to 140 deg F.
D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

F. Fasteners: Stainless-steel self-tapping screws.

G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.05 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation.
   2. Kolbi Pipe Marker Co.

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.06 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as “DANGER,” “CAUTION,” or “DO NOT OPERATE.”
PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.03 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Division 09.

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.


3.05 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For supply ducts.
2. Yellow: For exhaust ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.06 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

3.07 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION
SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.
B. Testing, adjustment, and balancing of hydronic systems.
C. Testing, adjustment, and balancing of refrigeration systems.
D. Measurement of final operating condition of HVAC systems.
E. Measuring electrical performance of HVAC equipment.
F. Setting quantitative performance of HVAC equipment.
G. Verifying that automatic control devices are functioning properly.
H. Sound measurement of equipment operating conditions.
I. Vibration measurement of equipment operating conditions.
J. Reporting results of activities and procedures specified in this Section.
K. Commissioning activities.

1.02 REFERENCE STANDARDS


1.03 DEFINITIONS

B. CAV: Constant air volume.
HMC Architects

C. cfm: Cubic feet per minute.


E. NC: Noise criteria.

F. TAB: Testing, adjusting, and balancing.

G. VAV: Variable air volume.

1.04 SUBMITTALS

A. See Division 01 for submittal procedures.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to the Commissioning Authority.
   2. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   3. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
   4. Include at least the following in the plan:
      a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
      b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
      c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
      d. Final test report forms to be used.
      e. Detailed step-by-step procedures for TAB work for each system and issue, including:
         1) Terminal flow calibration (for each terminal type).
         2) Diffuser proportioning.
         3) Branch/submain proportioning.
         4) Total flow calculations.
         5) Rechecking.
         6) Diversity issues.
      f. Expected problems and solutions, etc.
      g. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.
      h. Details of how TOTAL flow will be determined; for example:
         1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
         2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
      i. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
      j. Confirmation of understanding of the outside air ventilation criteria under all conditions.
k. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
l. Method of checking building static and exhaust fan and/or relief damper capacity.
m. Methods for making coil or other system plant capacity measurements, if specified.
n. Time schedule for TAB work to be done in phases (by floor, etc.).
o. Description of TAB work for areas to be built out later, if any.
p. Time schedule for deferred or seasonal TAB work, if specified.
q. False loading of systems to complete TAB work, if specified.
r. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
s. Interstitial cavity differential pressure measurements and calculations, if specified.
t. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
u. Procedures for formal progress reports, including scope and frequency.
v. Procedures for formal deficiency reports, including scope, frequency and distribution.

C. Field Logs: Submit at least twice a week to Commissioning Authority.

D. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

E. Progress Reports.
1. As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

F. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
1. Submit under provisions of Division 01.
2. Submit to the Commissioning Authority within two weeks after completion of testing, adjusting, and balancing.
3. Revise TAB plan to reflect actual procedures and submit as part of final report.
4. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
5. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
6. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
7. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing agent.
8. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std. 111.
9. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
10. Include the following on the title page of each report:
   a. Name of Testing, Adjusting, and Balancing Agency.
   b. Address of Testing, Adjusting, and Balancing Agency.
   c. Telephone number of Testing, Adjusting, and Balancing Agency.
   d. Project name.
   e. Project location.
   f. Project Architect.
   g. Project Engineer.
   h. Project Contractor.
   i. Project altitude.
   j. Report date.
11. In addition to certified field report data, include the following:
   a. Pump curves.
   b. Fan curves.
   c. Manufacturers’ test data.
   d. Field quality-control test reports prepared by system and equipment installers.
   e. Other information relative to equipment performance, but do not include approved Shop Drawings and Product Data.
12. Signature of testing, adjusting, and balancing Agent who certifies the report.
13. Summary of contents, including the following:
   a. Design versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.
14. Notes to explain why certain final data in the body of reports vary from design values.
15. Test conditions for fans and pump performance forms, including the following:
   a. Settings for outside-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings, including settings and percentage of maximum pitch diameter.
   f. Settings for supply-air, static-pressure controller.
   g. Other system operating conditions that affect performance
16. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present with single-line diagrams and include the following:
   a. Quantities of outside, supply, return, and exhaust airflows.
   b. Water flow rates.
   c. Duct, outlet, and inlet sizes.
   d. Pipe and valve sizes and locations.
   e. Terminal units.
   f. Balancing stations.
17. Noise and Vibration Measurement Tests: Performed in accordance with ASHRAE handbook guidelines and only after air and water balance is complete. Noise measurements should be reported in octave bands and overall NC rating by space.
18. Title 24 Acceptance Tests: Perform all functions and tests required by Title 24 acceptance tests. Identify and make any system adjustments to achieve
acceptance testing objectives. Complete acceptance testing forms and submit to Engineer and General Contractor.

G. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 QUALITY ASSURANCE

A. Agent Qualifications: Engage a testing, adjusting, and balancing agent certified by AABC.

B. Certification of Testing, Adjusting, and Balancing Reports: Certify testing, adjusting, and balancing field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified testing, adjusting, and balancing reports.
   2. Certify that testing, adjusting, and balancing team complied with approved testing, adjusting, and balancing plan and procedures specified and referenced in this Specification.

C. Testing, Adjusting, and Balancing Reports: Use standard forms from AABC’s “National Standards or Testing, Adjusting and Balancing.”

D. Instrumentation Type, Quantity and Accuracy: As described in AABC national standards.

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.

3.02 PROJECT CONDITIONS

A. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner’s operations.

3.03 COORDINATION

A. Coordinate efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Perform testing, adjusting, and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

C. If another round of pressure testing of the raised floor assembly is required after the first testing, verify that all trades have completed their work to mitigate areas of leakage before commencing additional test.
3.04 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC’S “National Standards” forms stating that AABC will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing the requirements of the Contract Documents if the testing, adjusting, and balancing Agent fails to comply with the Contract Documents. Guarantee includes the following provisions:
1. The certified Agent has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

3.05 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
1. AABC MN-1, AABC National Standards for Total System Balance.
5. Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

D. TAB Agency Qualifications:
1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
2. Having minimum of three years documented experience.

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

F. TAB Supervisor Qualifications: Professional Engineer licensed in California.

3.06 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
1. Examine the Contract Documents to become familiar with project requirements and to discover conditions in systems’ designs that may preclude proper testing, adjusting, and balancing of systems and equipment.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

3. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

4. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

5. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

6. Systems are started and operating in a safe and normal condition.

7. Temperature control systems are installed complete and operable.

8. Proper thermal overload protection is in place for electrical equipment.

9. Final filters are clean and in place. If required, install temporary media in addition to final filters.

10. Duct systems are clean of debris.

11. Fire and volume dampers are in place and open.

12. Air coil fins are cleaned and combed.

13. Examine open-piping-system pumps to ensure absence of entrained air in suction piping.

14. Examine equipment for installation and for properly operating safety interlocks and controls.

15. Access doors are closed and duct end caps are in place.

16. Air outlets are installed and connected.

17. Duct system leakage is minimized.

18. Hydronic systems are flushed, filled, and vented.

19. Pumps are rotating correctly.

20. Proper strainer baskets are clean and in place.

21. Service and balance valves are open.

22. Examine equipment performance data, including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredictable conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, “Fans and Systems,” Sections 7 through 10; or in SMACNA’s “HVAC Systems—Duct Design,” Sections 5 and 6. Compare this data with design data and installed conditions.

23. Examine automatic temperature system components to verify the following:
   a. Dampers, valves, and other controlled devices operate by the intended controller.
   b. Dampers and valves are in the position indicated by the controller.
   c. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   d. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
e. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
f. Sensors are located to sense only intended conditions.
g. Sequence of operation for control modes is according to the Contract Documents.
h. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
i. Interlocked systems are operating.
j. Changeover from heating to cooling mode occurs according to design values.

B. Examine installed raised floor assembly prior to testing. Identify and key areas that are likely to cause excessive air leakage and report deficiencies discovered before and during performance of air leakage testing. Repeat examination prior to start of any additional pressure testing. Perform similar examination of mockup prior to start of pressure testing of mock-up.

C. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

D. Beginning of work means acceptance of existing conditions.

3.07 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers whose work will be tested, adjusted, or balanced.

B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect to facilitate spot checks during testing.

C. Provide additional balancing devices as required.

D. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
   7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   8. Windows and doors can be closed so design conditions for system operations can be met.

3.08 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.09 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

G. Check and adjust systems approximately six months after final acceptance and submit report.

3.10 GENERAL PROCEDURES

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

B. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.11 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

C. Measure air quantities at air inlets and outlets.
D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

L. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

M. Check multi-zone units for motorized damper leakage. Adjust air quantities with mixing dampers set first for cooling, then heating, then modulating.

N. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

O. On fan powered VAV boxes, adjust air flow switches for proper operation.

3.12 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.

B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
HMC Architects

C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

D. Effect system balance with automatic control valves fully open to heat transfer elements.

E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

G. Hydronic system flows shall be balanced at the pump by setting the appropriate frequency on the Variable Frequency Drive. Under no circumstances shall it be acceptable to balance a pump or system flow by throttling or turning down an isolation valve at the pump. Hydronic system balancing shall occur with pump isolation valves at their full 100 percent open position.

H. Flow across control valves shall be measured by means of two sample ports (Pete’s Plugs) located immediately adjacent to the inlet and outlet, respectively, of the control valve. These ports shall be used to obtain the pressure drop across the control valve at its full open position. The control valve Cv shall then be used to calculate the flow rate through the valve. The manual shutoff valve shall be used to provide balance throttling only where necessary and required by the design, with the balanced position noted by a permanent mark spanning from the valve handle to stationary valve body.

3.13 SOUND AND VIBRATION TESTS

A. Perform sound and vibration tests after air and water balance is complete. Measurements should be performed with HVAC and plumbing equipment on and HVAC and plumbing equipment off.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial testing, adjusting, and balancing procedures were not performed during near-peak summer and winter conditions, perform additional inspections, testing, and adjusting during near-peak summer and winter conditions.

3.15 COMMISSIONING

A. Perform prerequisites prior to starting commissioning activities.

B. Fill out Prefunctional Checklists for:
   1. Air side systems.
   2. Water side systems.
C. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.

D. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for all of the air handlers.
1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
2. Use the same test instruments as used in the original TAB work.
3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
4. For purposes of re-check, failure is defined as follows:
   a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
   b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
   c. Temperatures: Deviation of more than one deg F.
   d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.

E. In the presence of the Commissioning Authority, verify that:
1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

F. No seasonal tests are required.

G. No further monitoring is required.

H. No deferred testing is required.
3.16 MINIMUM DATA TO BE REPORTED

A. General:
1. A certification sheet at the front of the report’s binder, signed and sealed by the certified testing and balancing engineer.
2. A list of instruments used for procedures, along with proof of calibration.
3. Nomenclature sheets for each item of equipment.
4. Notes to explain why certain final data in the body of reports vary from indicated values.
5. Description of system operation sequence if it varies from the Contract Documents.
7. Design and actual values for measurements below.

B. Testing Instruments:
1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

C. Air Handling Units:
1. Total airflow rate in cfm.
2. Total system static pressure in inches wg.
3. Fan rpm.
4. Discharge static pressure in inches wg.
5. Filter static-pressure differential in inches wg.
7. Outdoor airflow in cfm.
8. Return airflow in cfm.
10. Return-air damper position.

D. Electric Motors:
1. Model/Frame
2. HP/BHP
3. Phase, voltage, amperage; nameplate, actual, no load
4. RPM
5. Service factor
6. Starter size, rating, heater elements
7. Sheave Make/Size/Bore

E. V-Belt Drives:
1. Identification/location
2. Required driven RPM
3. Driven sheave, diameter and RPM
4. Belt, size and quantity
5. Center to center distance, maximum, minimum, and actual

F. Ducts:
1. System and air-handling-unit number.
2. Location and zone.
3. Traverse air temperature in deg F.
4. Duct static pressure in inches wg.
5. Duct size in inches.
6. Duct area in sq. ft.
7. Airflow rate in cfm.
8. Velocity in fpm.

G. Pumps:
1. Identification/number
2. Manufacturer
3. Size/model
4. Impeller
5. Service
6. Design flow rate, pressure drop, BHP
7. Actual flow rate, pressure drop, BHP
8. Discharge pressure
9. Suction pressure
10. Total operating head pressure
11. Shut off, discharge and suction pressures
12. Shut off, total head pressure

H. Vibration Tests

I. Other Equipment:
1. Model number
2. Serial number
3. Rated capacity

END OF SECTION
SECTION 23 07 13
HVAC DUCT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
   1. Duct insulation.
   2. Fire-rated insulation.
   3. Insulation jackets.

B. Related Sections:
   1. Division 01 - Volatile Organic Compound (VOC) Content Restrictions.
   2. Division 07 - Firestopping.
   3. Division 09 - Painting and Coating: Painting insulation jackets.
   4. Section 23 05 53 - Identification for HVAC Piping and Equipment.
   5. Section 23 31 00 – HVAC Metal Ducts.

1.03 REFERENCE STANDARDS
1.04 ACTION SUBMITTALS

A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.

B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

C. Manufacturer’s Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved. Include details for removable insulation sections at access panels.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum five (5) years of experience and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping. Any insulation subjected to moisture shall not be used.

C. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Requirements for all products of this section:
   1. Surface Burning Characteristics:
      a. Indoor insulation: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.
      b. Outdoor insulation: Flame spread/Smoke developed index of 75/150, maximum, when tested in accordance with ASTM E 84, NFPA 255, or UL 723.
   2. Products shall not contain PVC, asbestos, lead, mercury, or mercury compounds.
   3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
   4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
   5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Glass fiber, flexible:
   1. Manufacturer:
      a. Knauf Insulation.
      c. Owens Corning Corporation.
      d. CertainTeed Corporation.
   2. Insulation: ASTM C553; flexible, noncombustible blanket with a thermosetting resin.
      a. Density / Thermal Conductivity ('K' value):
         1) 0.75 pcf / K = 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
         2) 1.0 pcf / K = 0.33 at 75 degrees F, when tested in accordance with ASTM C518.
         3) 1.5 pcf / K = 0.31 at 75 degrees F, when tested in accordance with ASTM C518.
      c. Maximum Water Vapor Sorption: 5.0 percent by weight.

C. Glass fiber, rigid:
   1. Manufacturer:
      a. Knauf Insulation.
c. Owens Corning Corp.
d. CertainTeed Corporation.

2. Insulation: ASTM C612; rigid, noncombustible board.
   a. Density / Thermal Conductivity (‘K’ value):
      1) 1.6 pcf / K = 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
      2) 3.0 pcf / K = 0.23 at 75 degrees F, when tested in accordance with ASTM C518.
      3) 6.0 pcf / K = 0.22 at 75 degrees F, when tested in accordance with ASTM C518.
   b. Maximum service temperature: 450 °F.
   c. Maximum Water Vapor Sorption: 5.0 percent.

2.02 FIRE-RATED INSULATION

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a fire rating by an NRTL acceptable to authorities having jurisdiction.

B. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a fire rating by an NRTL acceptable to authorities having jurisdiction.

C. Fire Rating: to suit architectural assembly, refer to Architectural Drawings.

2.03 JACKETS

A. All Service Jacket (ASJ): ASTM C1136.
   1. Vapor retarder laminate of reinforced bleached white kraft / foil.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.

   1. Vapor retarder laminate of foil / scrim / kraft construction.
   2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.

   1. Thickness: 0.016 inch sheet.
   2. Finish: Stucco embossed.
   4. Fittings: 0.016 inch inch thick die shaped fitting covers with factory attached protective liner.

D. Aluminum Outdoor Jacket (Alum Outdoor).
   2. UV-resistant.
E. Accessories:
   2. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-
      discharge welding and galvanized speed washer. Pin length sufficient for
      insulation thickness indicated.

PART 3 - EXECUTION

3.01 EXAMINATION

   A. Verify that ducts have been pressure tested before applying insulation materials.
   B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

   A. Install in accordance with manufacturer's instructions.
   B. Install in accordance with NAIMA National Insulation Standards.
   C. Use accessories compatible with insulation materials and suitable for the service. Use
      accessories that do not corrode, soften, or otherwise attack insulation or jacket in
      either wet or dry state.
   D. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a
      vapor retarder.
   E. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints
      with adhesive recommended by the insulation material manufacturer.
   F. Apply insulation with the least number of joints practical.
   G. Apply insulation over fittings and specialties, with continuous thermal and vapor-
      retarder integrity, unless otherwise indicated. Where service access is required,
      provide removable insulation sections that allow for removal and replacement without
      damaging surrounding insulation. At nameplates, bevel and seal ends of insulation.
   H. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in
      insulation at hangers, supports, anchors, and other projections with vapor-retarder
      mastic. Apply insulation continuously through hangers and around anchor
      attachments.
   I. Hangar Inserts.
      1. For support points of rectangular or oval ducts supported by trapeze hangers,
         place weight supporting insulation at bottom of duct over trapeze. Weight
         supporting insulation shall be rigid glass fiber insulation having minimum of 6 pcf
         density and 200 lb/ft compression strength at 10% deformation and minimum 6
         inch long with same thickness as insulation specified. Weight supporting inserts
         similar to HAMFAB H-block by ICA Inc. may be used for rectangular ducts less
         than 18 inches. Follow manufacturer's recommendation for number of inserts.
2. For support points of round ducts smaller than 16 inch diameter, weight supporting insulation is not required for either rigid or flexible glass fiber insulation.
3. For support points of round ducts 16 inch diameter and larger, place weight supporting insulation between duct and strap or trapeze.
4. Flexible glass fiber insulation may be installed outside of support for round ducts 24 inch diameter or smaller, provided vapor barrier integrity is maintained at rod / strap penetration.

J. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

K. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

L. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

M. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

N. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

O. External Duct Insulation Application:
1. Secure insulation with vapor barrier and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Secure insulation without vapor barrier with staples or tape.
3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

3.03 FIELD QUALITY CONTROL

A. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.04 SCHEDULES

A. Items Not Insulated:
1. Double-wall metal ducts which comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.
7. Transfer air ducts.
8. Ductwork located in the space it is serving.

B. Location definitions:
   1. Concealed: ductwork in ceilings and shafts.
   2. Exposed: ductwork that is not concealed, but also not in occupied spaces such as ductwork in mechanical rooms.
   3. Occupied: ductwork in occupied rooms, not serving the room through which it is passing.

C. Insulation thickness shall be adjusted as necessary to meet code requirements.

**Table: DUCT INSULATION**

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Insulation</th>
<th>Minimum Thickness</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply / Outside Air</td>
<td>Outdoor</td>
<td>Fiber Board 6.0 pcf or Fiber Wrap 1.5 pcf</td>
<td>2.0 inch</td>
<td>Alum Outdoor</td>
</tr>
<tr>
<td></td>
<td>Concealed</td>
<td>Fiber Board 1.6 pcf or Fiber Wrap 0.75 pcf</td>
<td>1.5 inch</td>
<td>FSK</td>
</tr>
<tr>
<td></td>
<td>Exposed up to 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td></td>
<td>Occupied</td>
<td></td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td>Return / Exhaust</td>
<td>Outdoor</td>
<td>Fiber Board 6.0 pcf or Fiber Wrap 1.5 pcf</td>
<td>2.0 inch</td>
<td>Alum Outdoor</td>
</tr>
<tr>
<td>upstream of heat recovery</td>
<td>Concealed</td>
<td>Fiber Board 1.6 pcf or Fiber Wrap 0.75 pcf</td>
<td>1.5 inch</td>
<td>FSK</td>
</tr>
<tr>
<td></td>
<td>Exposed up to 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF</td>
<td></td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
</tbody>
</table>

END OF SECTION
 SECTION 23 07 16

HVAC PIPING AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Pipe and equipment insulation.
   2. Pipe and Equipment jackets.

B. Related Sections:
   1. Division 01 – Volatile Organic Compound (VOC) Content Restrictions.
   2. Division 07 – Firestopping.
   3. Division 09 – Painting and Coating: Painting insulation jackets.
   4. Section 23 05 53 – Identification for HVAC Piping and Equipment.
   5. Section 23 21 13 – Hydronic Piping.

1.03 REFERENCE STANDARDS


1.04 ACTION SUBMITTALS
A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.
B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
C. Manufacturer’s Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved. Include details for removable insulation sections at access panels.

1.05 INFORMATIONAL SUBMITTALS
A. Qualification Data: For qualified Installer.
B. Field quality-control reports.

1.06 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.
B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum five (5) years of experience and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Accept materials on site in original factory packaging, labelled with manufacturer’s identification, including product density and thickness.
B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping. Any insulation subjected to moisture shall not be used.
C. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS
2.01 PIPE AND EQUIPMENT INSULATION
A. Requirements for all products of this section:
   1. Surface Burning Characteristics:
      a. Indoor insulation: Flame spread/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.
      b. Outdoor insulation: Flame spread/Smoke developed index of 75/150, maximum, when tested in accordance with ASTM E84, NFPA 255, or UL 723.
   2. Products shall not contain PVC, asbestos, lead, mercury, or mercury compounds.
Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.
   1. Manufacturers:
      a. Aeroflex USA.
      b. Armacell LLC.
      c. K-Flex USA LLC.
      d. Armstrong World Industries.

C. Mineral Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type II. Maximum moisture absorption: 0.2 percent by volume.
   1. Manufacturers:
      a. Knauf Insulation.
      c. Owens Corning Corporation.
   2. CertainTeed Corporation.

D. Mineral Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less.
   1. Manufacturers:
      a. Knauf Insulation.
      c. Owens Corning Corporation.
   2. CertainTeed Corporation.

2.02 PIPE AND EQUIPMENT JACKETS

A. Aluminum Jacket: ASTM B209 formed aluminum sheet. Thickness 0.016 inch; smooth finish, longitudinal slip joints and 2 inch laps, 0.016 inch thick die shaped fitting covers with factory-attached protective liner; stainless steel bands.

B. All Service Jacket (ASJ): ASTM C291, laminated glass-fiber-reinforced, flame retardant kraft paper and aluminum foil. Moisture permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that ducts have been pressure tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 PIPE AND EQUIPMENT INSULATION INSTALLATION

A. Install in accordance with manufacturer’s instructions.
B. Install in accordance with NAIMA National Insulation Standards.

C. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

D. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

F. Apply insulation with the least number of joints practical.

G. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

H. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

I. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

J. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

K. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

L. Exposed Piping and equipment: Locate insulation and cover seams in least visible locations.

M. Insulated pipes: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints with molded insulation of like material and thickness as adjacent pipe.

N. For hot piping, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.

O. Inserts and Shields:
   1. Application: Piping 1-1/2 inches diameter or larger.
   2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
   3. Insert location: Between support shield and piping and under the finish jacket.
   4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
   5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
P. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Division 07.

Q. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

R. Finish insulation at supports, protrusions, and interruptions.

S. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.

3.03 FIELD QUALITY CONTROL

A. Inspect work, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall include all equipment and be limited to one location for each duct or pipe system.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.04 SCHEDULES

A. Pipe Items Not Insulated:
   1. Drainage piping located in crawl spaces.
   2. Chrome-plated piping and fittings.

B. Location definitions:
   1. Concealed: located in ceilings and shafts.
   2. Exposed: not concealed, but also not in occupied spaces such as in mechanical rooms.
   3. Occupied: located in occupied rooms.

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Insulation</th>
<th>Minimum Thickness</th>
<th>Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Hot Water Equipment, Chilled Water Pumps and Heat Exchangers</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Board Fiber Board</td>
<td>2.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Board Fiber Board</td>
<td>2.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Air Separators and Expansion Tanks</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Board Fiber Board</td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Board Fiber Board</td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Heating Hot Water Piping, NPS 1-1/2” and larger</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Heating Hot Water Piping, NPS 1-1/4” and smaller</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8’ AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Piping,</td>
<td>Exposed up to 8’ AFF</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>Alum</td>
</tr>
<tr>
<td>Type</td>
<td>Location</td>
<td>Insulation</td>
<td>Minimum Thickness</td>
<td>Jacket</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-----------------------------------</td>
<td>--------------</td>
<td>-------------------</td>
<td>--------</td>
</tr>
<tr>
<td>NPS 1-1/2” and larger</td>
<td>Exposed above 8' AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>1.0 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Chilled Water Piping, NPS 1-1/4” and smaller</td>
<td>Exposed up to 8' AFF</td>
<td>Mineral Fiber</td>
<td>0.5 inch</td>
<td>Alum</td>
</tr>
<tr>
<td></td>
<td>Exposed above 8' AFF, Concealed</td>
<td>Mineral Fiber</td>
<td>0.5 inch</td>
<td>ASJ</td>
</tr>
<tr>
<td>Refrigerant Piping</td>
<td>Any</td>
<td>Elastomeric</td>
<td>1.0 inch</td>
<td>None</td>
</tr>
<tr>
<td>Condensate Drains</td>
<td>Any</td>
<td>Elastomeric</td>
<td>0.5 inch</td>
<td>None</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. SECTION INCLUDES
   1. Chilled and Heating Hot Water piping, above grade.
   2. Chilled and Heating Hot Water piping, buried.
   3. Pipe hangers and supports.
   4. Unions, flanges, mechanical couplings, and dielectric connections.

B. Related Requirements:
   1. Section 23 05 23 “General Duty Valves for HVAC Piping”.
   2. Section 23 21 16 “Hydronic Piping Specialties”.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe.
   2. Fittings.

B. Sustainable Design Submittals:
   1. Product Data: For adhesives, indicating VOC content.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.
   4. Interior wall and soffit framing

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.
1.05 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
   3. Certificate described above is not valid unless it has been issued while welder was working for his current employer, and unless welder has performed type of work described by certificate in preceding 3 months.

D. The Owner’s Representative reserves the right to test the work of any welder employed on the project, at the Owner’s expense. If the work of the welder is found to be unsatisfactory, the welder shall be prevented from doing further welding on the project and all defective welds replaced.

E. The Owner may, at the Owner’s expense, initially x-ray inspect welds in accordance with ANSI B31.9. Welds not in conformance will be replaced by the contractor at his expense. Costs of x-raying the new weld will be borne by the contractor.

1.06 WARRANTY

A. Manufacturer shall warrant pipe and fittings for 10 years to be free of defects in materials or workmanship.

B. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or workmanship.

PART 2 - PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

A. Comply with ASME B31.9 and applicable federal, state, and local regulations.

B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:
   1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
   2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
4. Pipe elbows shall be long radius (1.5 diameter fittings).

C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.

D. Valves: Provide valves where indicated.

E. Piping shall be made in America.

F. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
   1. Heating Hot Water Heating Piping: 125 psig at 200 deg F.
   2. Chilled Water Piping: 150 psig at 120 deg F.
   3. Condensate-Drain Piping: 120 deg F.
   4. Air-Vent Piping: 200 deg F.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B88, Type K.

C. DWV Copper Tubing: ASTM B306, Type DWV.

D. Wrought-Copper Fittings and Unions: ASME B16.22.

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in “Piping Applications” Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in “Piping Applications” Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in “Piping Applications” Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, and 300 as indicated in “Piping Applications” Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125, and 250; raised ground face, and bolt holes spot faced as indicated in “Piping Applications” Article.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.
G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

2.04 HYDRONIC WATER PIPING, BURIED

A. Pre-insulated, HDPE-Jacketed, Steel Piping System:
   1. Carrier pipe shall be carbon steel, ASTM A-53, Grade B, std weight. Straight sections of factory insulated pipe shall have 6" of exposed pipe at each end for field joint fabrication.
   2. Insulation shall be polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket with a minimum thickness of 1.5 inches for pipe sizes greater than 6". Insulation shall be rigid, 90-95% closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K- Factor) of 0.16 and shall conform to ASTM C-591. Maximum operating temperature shall not exceed 250°F. Insulation thickness shall be specified by calling out appropriate carrier pipe and jacket size combinations, and shall not result in less than required thickness.
   3. Jacket: Jacketing material shall be extruded, black, high density polyethylene (HDPE), having a minimum wall thickness of 100 mils for pipe sizes equal to or less than 12", 125 mils for jacket sizes greater than 12" to 24", and 150 mils for jacket sizes greater than 24". Jacket shall conform with ASTM D-3350. The inner surface of the HDPE jacket shall be oxidized by means of corona treatment, flame treatment (patent pending), or other approved methods. This will ensure a secure bond between the jacket and foam insulation preventing any ingress of water at the jacket/ foam interface.
   4. Straight run joints: Straight run joints shall be field insulated using urethane foam to the thickness specified and jacketed with a heat shrinkable sleeve over the HDPE sleeve mold or sealed with heat shrink tape. Joints can be made beside the trench or inside the trench.
   5. Fittings: Pre-fabricated and pre-insulated fittings with polyurethane foam, jacketed with a one-piece seamless molded HDPE fitting cover, and a butt fusion welded HDPE jacket. Carrier pipe fittings shall be butt-welded. Elbows, loops, offsets, or any other direction changes shall conform to the standards set by ASME B31.1, Code for Power Piping.
   6. Flexible expansion joints: Ductile iron, conforming to the material requirements of ASTM A536 and ANSI/AWWA C153/A21.53, designed and cast as an integral part of a ball and socket type flexible joint, having a minimum per ball deflection of 15 degrees and 4-inches minimum expansion. Provide polyethylene sleeves, meeting ANSI/AWWA C105/A21.5. All internal surfaces (wetted parts) shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213. Sealing gaskets shall be constructed of EPDM. The coating shall meet ANSI/NSF-61. 5. Exterior surfaces shall be coated with a minimum of 6 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/ AWWA C116/A21.16. Basis of Design: EBAA Iron Flextend.
2.05 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.06 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

A. Unions for Pipe 2 inches and Under:

B. Flanges for Pipe Over 2 inches:

C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
   1. Dimensions and Testing: In accordance with AWWA C606.
   2. Mechanical Couplings: Comply with ASTM F1476.
   4. When pipe is field grooved, provide coupling manufacturer’s grooving tools.

D. Dielectric Connections: Red brass dielectric nipple.

PART 3 - EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.

C. Remove scale and dirt on inside and outside before assembly.

D. Prepare piping connections to equipment using jointing system specified.

E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

F. After completion, fill, clean, and treat systems.
HMC Architects

3.02 INSTALLATION

A. Install in accordance with manufacturer’s instructions.
B. Pipe elbows shall be long radius (1.5 diameter fittings).
C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
D. Install piping to conserve building space and to avoid interfere with use of space.
E. Group piping whenever practical at common elevations.
F. Slope piping and arrange to drain at low points.
G. Install piping to permit valve servicing.
H. Install piping to allow application of insulation.
I. Select system components with pressure rating equal to or greater than system operating pressure.
J. Install unions in piping, NPS 2-1/2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
K. Install flanges in piping, NPS 3 and larger, at final connections of equipment and elsewhere as indicated.
L. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
M. Install shutoff valve immediately upstream and downstream of each dielectric fitting.
N. Comply with requirements in Section 23 05 16 “Expansion Fittings and Loops for HVAC Piping” for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
O. Comply with requirements in Section 23 05 53 “Identification for HVAC Piping and Equipment” for identifying piping.
P. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Division 01.
Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 00 00.
R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 00 00.
S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 00 00.
T. Underground Piping installation:
1. Field-engineered piping systems shall be fabricated from factory insulated sections of straight pipe and fittings. When practical, piping shall be provided in 40-foot double-random lengths. All piping shall have ends cut square in preparation for butt welding.

2. Carrier pipe joining shall be accomplished via butt welding.

3. Underground systems shall be buried in a trench of not less than 18 inches deeper than the top of the pipe and not less than eighteen inches wider than the combined O.D. of all piping systems. A minimum thickness of 24 inches of compacted backfill over the top of the pipe, to meet H-20 highway loading, is required whenever the pipe passes below a service or high-traffic roadway.

4. Trench bottom shall have a minimum of 6” of sand, pea gravel, or specified backfill material as a cushion for the piping. All field cutting of the pipe shall be performed in accordance with the manufacturer’s installation instructions.

5. A hydrostatic pressure test shall be performed before insulating the field joints or burying the system and shall be performed per the Engineer’s specifications. The factory recommended pressure test consists of an expansion phase and a test phase. Care shall be taken to insure all trapped air is removed from the system prior to the test. The expansion phase consists of an initial pressurization period of three hours at 1.5 times the normal system operating pressure. Makeup water shall be added to the system during this period to maintain the desired pressure. The test shall commence immediately after the expansion phase. The pressure shall be reduced by 10 psi and the test clock started. System pressure remaining within 5% of the target test pressure for one hour indicates no leakage has occurred. If the entire test procedure cannot be completed within eight hours of the initial pressurization, the system shall be de-pressurized and allowed to relax for a minimum of eight hours before another test is attempted. The piping system shall be restrained from uncontrolled movement in the event of a failure. Appropriate safety precautions shall be taken to guard against possible injury to personnel in the event of a failure.

6. Piping installed below grade shall be provided with means to resist hydrodynamic uplift forces. This could include, but not limited to, concrete anchors and pipe straps.

7. Support underground piping at slab penetration. Follow manufacturer’s recommendations for hanger spacing and rod size.

3.03 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 05 19 “Meters and Gauges for HVAC Piping.”

3.04 ADJUSTING

A. Mark calibrated nameplates of pump discharge valves after hydronic system balancing has been completed, to permanently indicate final balanced position.

B. Perform these adjustments before operating the system:
1. Open valves to fully open position. Close coil bypass valves.
2. Check pump for proper direction of rotation.
3. Set automatic fill valves for required system pressure.
4. Check air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Check operation of automatic bypass valves.
7. Check and set operating temperatures of boilers, chillers, and cooling towers to design requirements.
8. Lubricate motors and bearings.

3.05 HANGERS AND SUPPORTS

A. Comply with requirements in Section 23 05 29 “Hangers and Supports for HVAC Piping and Equipment” for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 23 05 48 “Vibration and Seismic Controls for HVAC” for seismic restraints.

C. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe, or steel hangers with felt insert.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 7 feet.
   2. NPS 1: Maximum span, 7 feet.
   3. NPS 1-1/2: Maximum span, 9 feet.
   4. NPS 2: Maximum span, 10 feet.
   5. NPS 2-1/2: Maximum span, 11 feet.
   6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
   2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
   3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
   4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
   6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
   7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.
3.06 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

3.07 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
   1. Leave joints, including welds, uninsulated and exposed for examination during test.
   2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
   3. Isolate expansion tanks and determine that hydronic system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the “SE” value in Appendix A in ASME B31.9, “Building Services Piping.”
   5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   6. Prepare written report of testing.

C. Perform the following before operating the system:
   1. Open manual valves fully.
   2. Inspect pumps for proper rotation.
   3. Set makeup pressure-reducing valves for required system pressure.
   4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
   5. Set temperature controls so all coils are calling for full flow. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
   6. Verify lubrication of motors and bearings.
### 3.08 PIPE SCHEDULE

<table>
<thead>
<tr>
<th>Location</th>
<th>Size</th>
<th>Material</th>
<th>Fittings</th>
<th>Joining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled / Heating Hot Water</td>
<td>Above Ground</td>
<td>Up to 3”</td>
<td>CU-L</td>
<td>Wrought – Copper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Steel Sch 40</td>
<td>Mallable Iron</td>
<td>Threaded / Welded / Grooved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4” &amp; above</td>
<td>Wrought – Steel</td>
<td>Threaded / Welded / Grooved</td>
</tr>
<tr>
<td>Below Ground</td>
<td>All</td>
<td>Carbon Steel; HDPE jacket; Pre-insulated: 1-1/2” HHW, 1” CHW</td>
<td>Prefabricated to match system</td>
<td>Welded</td>
</tr>
<tr>
<td>Mechanical Rooms</td>
<td>All</td>
<td>Steel Sch 40</td>
<td>Grooved</td>
<td>Mechanical</td>
</tr>
<tr>
<td>Makeup Water</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>Wrought – Copper</td>
</tr>
<tr>
<td>Condensate</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>DWV</td>
</tr>
<tr>
<td>Air Vent</td>
<td>All</td>
<td>All</td>
<td>CU-K</td>
<td>N/A</td>
</tr>
<tr>
<td>Safety Vent</td>
<td>All</td>
<td>All</td>
<td>CU-L</td>
<td>DWV</td>
</tr>
</tbody>
</table>

**END OF SECTION**
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes special-duty valves and specialties for the following:
   2. Relief valves.
   3. Air vents.
   4. Air separators.
   5. Expansion tanks.
   7. Pressure-temperature test plugs.
   8. Connectors.

B. Related Requirements:
   1. Section 23 05 23 “General Duty Valves for HVAC Piping”.
   2. Section 23 21 13 “Hydronic Piping”.
   3. Division 25 for automatic control valve and sensor specifications, installation requirements, and locations.

1.03 ACTION SUBMITTALS

A. Operation and Maintenance Data: to include in emergency, operation, and maintenance manuals.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
PART 2 - PRODUCTS

2.01 BALANCING VALVES

A. Manufacturers:
   1. Armstrong International, Inc
   2. ITT Bell & Gossett
   3. Taco, Inc.

B. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   3. Plug: Resin.
   4. Seat: PTFE.
   5. End Connections: Threaded or socket.
   7. Handle Style: Lever, with memory stop to retain set position.
   8. CWP Rating: Minimum 125 psig.
   9. Maximum Operating Temperature: 250 deg F.

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Body: Cast-iron or steel body, ball or butterfly pattern with calibrated orifice or venturi.
   2. Ball: Brass or stainless steel.
   4. Disc: Glass and carbon-filled PTFE.
   5. Seat: PTFE.
   6. End Connections: Flanged or grooved.
   8. Handle Style: Lever, with memory stop to retain set position.
  10. Maximum Operating Temperature: 250 deg F.

2.02 RELIEF VALVES

   1. Manufacturers:
      a. Tyco Flow Control.
      b. Armstrong International, Inc.
      c. ITT Bell & Gossett.
   2. Body: Bronze or brass.
   3. Disc: Glass and carbon-filled PTFE.
   5. Stem Seals: EPDM O-rings.
   6. Diaphragm: EPT.
   9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
2.03  AIR VENTS

A.  Manufacturers:
   1. Armstrong International, Inc
   2. ITT Bell & Gossett
   3. Taco, Inc.

B.  Manual Air Vents:
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Screwdriver or thumbscrew.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 225 deg F.

C.  Automatic Air Vents:
   1. Body: Bronze or cast iron.
   2. Internal Parts: Nonferrous.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 240 deg F.

2.04  EXPANSION TANKS:

A.  Bladder-Type Expansion Tanks:
   1. Manufacturers:
      a. Amtrol Inc.
      b. ITT Bell & Gossett.
      c. Taco, Inc.
   2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
   5. Tank drain.

2.05  AIR SEPARATORS:

A.  In-Line Air Separators:
   1. Manufacturers:
      b. ITT Bell & Gossett.
      c. Taco, Inc.
   2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
4. Maximum Operating Temperature: Up to 300 deg F.

2.06 STRAINERS
A. Y-Pattern Strainers:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. CWP Rating: 175 psig.

B. Grooved Joint Strainers:
1. Body: ASTM A536, ductile iron with access cap.
2. Coupling Gasket: Grade E EPDM.
3. Strainer Screen: Type 304 stainless-steel perforated screen.
4. CWP Rating: 750 psig.
5. Horizontal or vertical mounting.
6. Use with Grooved Joint System only.

2.07 PRESSURE-TEMPERATURE TEST PLUGS
A. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and EPDM rated for minimum 200 deg F.

B. Use extended length plugs to clear insulated piping.

2.08 CONNECTORS
A. Stainless-Steel Bellow, Flexible Connectors:
2. End Connections: Threaded or flanged to match equipment connected.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS
A. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.02 HYDRONIC SPECIALTIES INSTALLATION
A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

E. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

F. Install strainers on supply side of each control valve, pressure reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS ¾ nipple and ball valve in blow-down connection of strainers NPS 2 and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes the following HVAC water-treatment systems:
   1. Chemical-feed equipment and controls.

1.02 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for chemical treatment equipment, materials, and chemicals.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, attachment details and diagrams for power and control wiring.

1.03 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Other Informational Submittals:
   1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in “Performance Requirements” Article.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical treatment system to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.06 WARRANTY

A. Warranty Period: Two years from date of Substantial Completion on equipment.
PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems:
   1. Sequestrating agent to reduce deposits and adjust pH; polyphosphate.
   2. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium toyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
   3. Conductivity enhancers; phosphates or phosphonates.

2.02 CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
   2. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 23 05 13 “Common Motor Requirements for HVAC Equipment.”
      a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in “Performance Requirements” Article.

PART 3 - EXECUTION

3.01 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.02 INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. See Section 23 05 48 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Bypass Feeders: Install in closed hydronic systems and equipped with the following:
   1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
   2. Install water meter in makeup-water supply.
   3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
   4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
   5. Install a swing check on inlet after the isolation valve.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 23 21 13 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet.

E. See Division 22 for backflow preventers required in makeup-water connections to potable-water systems.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

3.05 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
5. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

END OF SECTION
SECTION 23 31 00
HVAC METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Ducts and fittings.
2. Sheet metal materials.
3. Flexible Ducts.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.
8. Duct leakage testing.

B. Related Sections:
1. Section 23 05 93 “Testing, Adjusting, and Balancing for HVAC” for testing, adjusting, and balancing requirements for metal ducts.
2. Section 23 07 13 “HVAC Duct Insulation”.
3. Section 23 33 00 “Air Duct Accessories” for dampers, duct silencers, duct-mouting access doors and panels, turning vanes, and flexible connections.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design
1. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible” and performance requirements and design criteria indicated in “Duct Schedule” Article.
2. Duct system has been design for low friction drop, both through straight duct and through fittings. Fitting types or duct sizes may be substituted only for those of equal to or lesser pressure drop, with written permission from engineer of record. Maximum duct aspect ratio shall be 3:1.
   a. Design pressure drop criteria:
      1) Supply, Return, Outside, and Transfer Air Ducts: maximum 0.05 in wg per 100 feet.
      2) Exhaust Air Ducts: maximum 0.08 in wg per 100 feet.
   b. Design velocity criteria:
      1) Outdoor ductwork or ductwork within a mechanical room: maximum 1,800 feet per minute.
      2) Ductwork in a shaft: 1,500 feet per minute.
3) Indoor ductwork not within a mechanical room or shaft: maximum 1,200 feet per minute.
4) Acoustical Consultant’s recommendations, which supersede above criteria.
5) Exhaust ductwork: minimum 1,000 feet per minute.

B. Duct system has been design for low friction drop, both through straight duct and through fittings. Fitting types or duct sizes may be substituted only for those of equal to or lesser pressure drop, with written permission from engineer of record. Maximum duct aspect ratio shall be 3:1.
   a. Design pressure drop criteria:
      1) Supply, Return, Outside, and Transfer Air Ducts: maximum 0.05 in wg per 100 feet.
      2) Exhaust Air Ducts: maximum 0.08 in wg per 100 feet.
   b. Design velocity criteria:
      1) Outdoor ductwork or ductwork within a mechanical room: maximum 1,800 feet per minute.
      2) Ductwork in a shaft: 1,500 feet per minute.
      3) Indoor ductwork not within a mechanical room or shaft: maximum 1,200 feet per minute.
      4) Acoustical Consultant’s recommendations, which supersede above criteria.
      5) Exhaust ductwork: minimum 1,000 feet per minute.

C. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible”, ASCE/SEI 7, and SMACNA’s “Seismic Restraint Manual: Guidelines for Mechanical Systems.”
   1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
   2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
   3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Flexible ducts.
   2. Liners and adhesives.
   3. Sealants and gaskets.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement details and spacing.
8. Seam and joint construction and sealing.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, flexible connectors, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK) – HVAC Air Duct Leakage Test Manual.
   1. Design Calculations: Calculations[, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation registered in the State of California] for selecting hangers and supports and seismic restraints.

1.05 INFORMATIONAL SUBMITTALS
A. Welding certificates.
B. Field quality-control reports.

1.06 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
B. Welding Qualifications: Qualify procedures and personnel according to the following:
C. REGULATORY REQUIREMENTS
   1. Construct ductwork to NFPA 90A standards.
D. FIELD CONDITIONS
   1. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
   2. Maintain temperatures within acceptable range during and after installation of duct sealants.
   3. Ductwork shall be transported to the site in enclosed vehicles or with ends capped.
   4. Do not store ductwork directly on ground or floor.
   5. Ductwork stored or stacked on site shall be capped.
   6. Installed duct shall be capped at the end of the day. Duct found uncapped after the end of the day shall be cleaned.
1.07 COORDINATION

A. Coordinate sizes and locations of concrete bases with casings and plenums. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.01 DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible” based on indicated static-pressure class unless otherwise indicated.

B. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

C. Duct systems shall not exceed deflection limits according to SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible."

D. Transverse Joints: Select joint types and fabricate according to SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible,” for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in round ducts larger than 60 Inches in Diameter: Flanged.

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

F. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 MATERIALS

A. General Material Requirements: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation (except as noted below): G60.
2. Galvanized Coating Designation for outside air intake ductwork, outdoor unjacketed ductwork, and as otherwise noted: G90.
3. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

G. Duct Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during transportation and construction.
   1. Product: DynAir Duct Protection Film or equivalent.
   2. High tack water-based adhesive.
   3. Thickness: 2 mils.
   4. UV stability.
   5. VOC content: zero.
   6. Elongation before break: minimum 325%.

2.03 FLEXIBLE DUCTS

A. Acoustically Rated, Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; vapor-barrier film.
   1. Manufacturers:
      a. Casco SF-181M.
      b. Flexmaster USA 1B.
      c. Thermaflex M-KE.
   2. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
   4. Temperature Range: Minus 20 to plus 175 deg °F.
   5. Water Vapor Permeance: maximum 0.17 perms (ASTM E 96, Procedure A).
   6. Insulation R-Value: R-4.2 minimum at 70 °F.
   7. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   8. NFPA 90A and NFPA 90B compliant.

B. Flexible Duct Attachment:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.04 DUCT LINER

A. General Requirements:
1. No fiberglass duct liner is allowed.
2. Service temperature: -20 °F to 250 °F.
3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
4. NFPA 90A and NFPA 90B compliant.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

B. Polyester Duct Liner:
1. Manufacturers:
   a. Ductmate - PolyArmor.
   b. Or engineer-approved equivalent.
2. K value: ASTM C518, 0.24 at 75 deg F; R-value per inch: 4.2.
3. Minimum Noise Reduction Coefficient (NRC): 0.65 at 1 inch thickness.
4. Maximum moisture sorption: 2% by weight.
5. Minimum 25% recycled content.
7. Water-Based Liner Adhesive.

C. Polyamide Foam Duct Liner:
1. Manufacturers:
   b. Or engineer-approved equivalent.
2. K value: ASTM C518, 0.30 at 75 deg F; R-value per inch: 3.3.
3. Minimum Noise Reduction Coefficient (NRC): 0.70 at 1 inch thickness.
4. Maximum moisture sorption: 2% by weight.
5. Mechanical Fasteners:
   a. Suitable for attachment to duct without damaging liner as recommended by manufacturer.
   b. Pin length: as required. Pin shall project no more than 1/8 inch into airstream.

2.05 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723 (ASTM E84); certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on or spray on.
2. Solids Content: Minimum 65 percent.
5. Mold and mildew resistant.
6. Volatile Organic Content (VOC): Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.

C. Flanged Joint Sealant: Single-component, acid-curing, silicone, elastomeric. Comply with ASTM C 920, Type S, Grade NS, Class 25, Use O.
1. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

**2.06 HANGERS AND SUPPORTS**

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

**2.07 SEISMIC-RESTRAINT DEVICES**

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
   1. Basis of Design: Mason SCB.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of at least 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
HMC Architects

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 23 33 00 "Air Duct Accessories" for fire and smoke dampers.


L. Exhaust duct in shower (wet) areas to be aluminum and sloped towards grilles.

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements. Comply with ASTM A780.

3.03 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." ASCE/SEI 7.
1. Space lateral supports a maximum of 40 feet on center, and longitudinal supports a maximum of 80 feet on center.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by the Office of Statewide Health Planning and Development for the State of California or an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.06 CONNECTIONS
A. Make connections to equipment with flexible connectors complying with Section 23 33 00 "Air Duct Accessories."
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.07 PAINTING
A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09.

3.08 DUCT CLEANING
A. Clean new duct system(s) before testing, adjusting, and balancing.

3.09 FIELD QUALITY CONTROL
A. Perform tests and inspections.
B. Leakage Tests:
   2. Test the following systems:
      a. Ducts with a Pressure Class of positive 3-Inch wg (0.75 kPa) or higher or negative 3-Inch wg (0.75 kPa) or lower: Test 100 percent of total installed duct area for each designated pressure class.
      b. Ducts with a Pressure Class between positive 2-Inch wg (0.5 kPa) and negative 2-Inch wg (0.5 kPa), inclusive: Test representative duct sections, selected by Design Engineer, totaling no less than 25 percent of total installed duct area for each designated pressure class.
      c. Welded Exhaust Ducts: Test 100 percent of total installed duct area for each designated pressure class.
   3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
   4. Test for leaks before applying external insulation.
   5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 DUCT SCHEDULE

Table: Duct Schedule

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MATERIAL</th>
<th>PRESSURE CLASS</th>
<th>RECT. LEAKAGE CLASS</th>
<th>ROUND LEAKAGE CLASS</th>
<th>SEAL CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Risers/Mains</td>
<td>Galvanized</td>
<td>+ 3&quot; w.g.</td>
<td>6</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Supply (before terminal boxes)</td>
<td>Galvanized</td>
<td>+ 2&quot; w.g.</td>
<td>12</td>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>Supply (after terminal boxes)</td>
<td>Galvanized</td>
<td>+ 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>Return</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Transfer</td>
<td>Galvanized</td>
<td>- 1&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Outside Air</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Exhaust</td>
<td>Galvanized</td>
<td>- 2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
<tr>
<td>Exhaust (in shower areas)</td>
<td>Aluminum</td>
<td>-2&quot; w.g.</td>
<td>24</td>
<td>12</td>
<td>C</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 23 33 00

HVAC DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Backdraft dampers.
   2. Barometric relief dampers.
   4. Control dampers.
   5. Fire dampers.
   7. Combination fire and smoke dampers.
   8. Turning vanes.
   9. Duct-mounted access doors.
   10. Flexible connectors.
   11. Duct accessory hardware.

B. Related Requirements:
   1. Division 07 for Firestopping.
   2. Section 23 31 00 “HVAC Metal Ducts” for flexible ducts.
   3. Division 26 for wiring connections.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      c. Control-damper installations.
      d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      e. Wiring Diagrams: For power, signal, and control wiring.
1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS


B. Comply with SMACNA’s "HVAC Duct Construction Standards – Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Provide duct accessories of materials suited to associated duct materials.

D. Air extractors shall not be used, except with the expressed written consent of the Design Engineer.

2.02 BACKDRAFT DAMPERS

A. General:
   1. Provide manufacturer’s standard backdraft damper if available as fan or air-moving equipment accessory.
   2. Provide damper material of the same material as associated ductwork.

B. Manufacturers:
   2. Pottorff.
   3. Ruskin Company.

C. Description: Gravity balanced.
3. Frame: 20 gage galvanized steel.
6. Blade Axles:
   a. Up to 42 inch damper width: Nonmetallic.
   b. 42 inch width and larger: Stainless steel.
7. Tie Bars and Brackets: Galvanized steel.
8. Accessories:
   a. Screen Type: Insect.
   b. 90-degree stops.

2.03 BAROMETRIC RELIEF DAMPERS

A. Description: Counterbalanced backdraft damper.
   1. Sensitivity: 0.01 inches wg differential pressure.
   2. Frame and blades: extruded aluminum.
   5. Accessories:
      a. Screen Type: Insect.

2.04 MANUAL VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories.
B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.
C. Damper material shall match associated ductwork.
D. Manufacturers:
   1. Ruskin.
   2. Louvers and Dampers.
E. Standard Manual Volume Dampers:
   1. Standard leakage rating, with linkage outside airstream.
   2. Suitable for horizontal or vertical applications.
   4. Maximum System Pressure: 2 inch wg.
   5. Blades:
      a. Opposed-blade design.
      b. [Include locking hand quadrant to hold single-blade dampers in a fixed position without vibration.]
2.05 CONTROL DAMPERS

A. Commercial Grade Control Dampers:
   1. Manufacturers:
      a. Ruskin Company.
      b. Pottorff.
      c. Nailor.
   2. Frames:
      a. 16 gage galvanized steel hat channel reinforced with corner braces.
   3. Blades:
      a. Multiple blade with maximum blade width of 8 inches.
      b. Opposed-blade design.
      c. 14 gage Galvanized-steel airfoil.
      d. Blade Edging: neoprene, mechanically secured to blade.
      e. Stainless steel jamb seals.
   4. Blade Axles: 1/2-inch-diameter; plated steel, operating temperature range from minus 25 to plus 250 deg F.
   7. Leakage Class 1. Testing according to AMCA Std. 500. Minimum ratings:
      a. System pressure: 3.5 inch wg.
      b. System velocity: 3,000 FPM.

B. Low Leakage Industrial Grade Control Dampers:
   1. Manufacturers:
      a. Ruskin Company.
      b. Pottorff.
      c. Nailor.
   2. Frames:
      a. 12 gage galvanized steel channel.
   3. Blades:
      a. Multiple blade with maximum blade width of 8 inches.
      b. Opposed-blade design.
      c. 16 gage Galvanized-steel airfoil.
      d. Blade Edging: EPDM, mechanically secured to blade.
      e. Stainless steel jamb seals.
   4. Blade Axles: 1/2-inch-diameter plated steel; blade-linkage hardware of stainless steel pivot pins with lock type retainers, with operating temperature range from minus 25 to plus 250 deg F.
   5. Bearings:
      a. Stainless-steel pressed into frame.
      b. Thrust washers at each end of vertical mounted blades.
   7. Leakage testing according to AMCA Std. 500. Minimum ratings:
      a. System pressure: 10 inch wg.
      b. System velocity: 4,000 FPM.

2.06 FIRE AND SMOKE DAMPERS

A. Manufacturers:
   1. Ruskin Company.
2. Louvers & Dampers, Inc.
3. Nailor Industries, Inc.

B. General Requirements:
1. Labeled according to UL 555C by an NRTL.
2. Fabricate in accordance with NFPA 90A
3. Comply with construction details for tested assemblies as indicated in UL’s “Fire Resistance Directory.”
4. Fire Rating: to suit wall, floor, ceiling, or corridor assembly, refer to Architectural Drawings.
5. Operational ratings: suited to meet duct pressure and velocity design airflow conditions.

C. Fire Dampers:
1. Type: Dynamic.
2. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg static pressure class and 2000-fpm velocity.
3. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, galvanized steel; with mitered and interlocking corners.
5. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

D. Smoke Dampers:
1. Smoke Detector: Integral, factory wired for single-point connection.
2. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg static pressure class and 2000-fpm velocity.
4. Leakage: Class I.
5. Actuator: electric, out of airstream, two-position, fail closed.

E. Combination Fire and Smoke Dampers:
1. Operational ratings: suited to meet design airflow conditions, and minimum 4-inch wg static pressure class and 2000-fpm velocity.
4. Smoke Detector: Integral, factory wired for single-point connection.
6. Provide galvanized steel factory sleeve.
7. Actuator: electric, out of airstream, two-position, fail closed.
8. Leakage: Class I.

2.07 TURNING VANES

A. Manufacturers:
1. Duro Dyne Inc.
2. Ductmate Industries.
3. Metalaire.
4. Ruskin.
B. General Requirements: Comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible”; Figures 4-3, “Vanes and Vane Runners,” and 4-4, “Vane Support in Elbows.”

C. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Single Wall: 3/4-inch trailing edge and 2 inch radius.
2. Double Wall: 2-inch inside radius. Vane length not to exceed 36 inches.

D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

2.08 DUCT-MOUNTED ACCESS DOORS

1. Door:
   a. Double wall; insulation fill and thickness as indicated for duct pressure class, minimum 1 inch.
   b. Hinges and Latches: continuous piano hinge and cam latches.
   c. Shape and material to match ductwork.
   d. Fabricate doors airtight and suitable for duct pressure class.
   e. Doors shall open against air pressure.
   f. On access doors on ducts of 4-inch wg pressure or greater, provide sign reading “CAUTION – DOOR CLOSES WITH AIR PRESSURE”.
2. Frame duct opening with continuous 1-inch by 1-inch angle. Provide sponge rubber or neoprene gasket at door-to-frame and frame-to-duct.

2.09 FLEXIBLE CONNECTORS

A. Manufacturers:
1. Durodyne.
2. Ventfabs.

B. Materials: Flame-retardant or noncombustible fabrics. NFPA 90A compliant.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's “HVAC Duct Construction Standards – Metal and Flexible” for metal ducts.

B. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless integral backdraft damper is provided, control damper is indicated, or otherwise indicated.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel. Provide elevated dial or shaft extension for insulated ducts.

D. Install cable-driven remote volume dampers for all volume dampers located in inaccessible ceilings or as indicated on Contract Drawings.
   1. Locate wall box within 50 feet in accessible location.
   2. Wall box shall be recessed-type in finished spaces.

E. Set dampers to fully open position before testing, adjusting, and balancing.
F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Fire Damper installation is required for all ductwork penetrating fire-rated walls, floors, and ceilings. Smoke damper installation is required for all ductwork penetrating smoke-rated partitions. Coordinate location and rating of fire and smoke dampers with Architectural Drawings. Provide dampers where required even if not shown on Mechanical Drawings.

I. Install fire and smoke dampers, with fusible links, according to manufacturer’s UL approved written instructions.

J. Locate duct silencers a minimum of two equivalent duct diameters from elbows and fittings.

K. Install duct security bars. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints and 1/2-inch-diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.

L. Install turning vanes in all rectangular elbows.
   1. Ductwork of pressure class ± 2-inch w.g. or lower: single wall vanes.
   2. Ductwork of pressure class ± 3-inch w.g. and greater: double wall vanes.
   3. Acoustical turning vanes are not to be used unless specifically indicated on the Contract Drawings.

M. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream or downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   7. At each change in direction and at maximum 50-foot spacing.
   8. Upstream or downstream from turning vanes.
   9. Control devices requiring inspection.
   10. Elsewhere as indicated.

N. Install access doors with swing against duct static pressure.

O. Access Door Sizes:
   1. Rectangular duct larger than 30 inches: 24 by 24 inches.
2. Rectangular duct up to 30 inches: 16 by 20 inches.
3. Rectangular duct up to 18 inches: 12 by 12 inches.
4. For ducts smaller than 18 inches: 2 inch x 2 inch length

P. Label access doors according to Section 23 05 53 “Identification for HVAC Piping and Equipment” to indicate the purpose of access door.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install flexible connectors to connect ducts to air-moving equipment.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION
SECTION 23 34 00

HVAC FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Centrifugal fans.
      a. Utility sets.
      b. Plenum fans.
   2. Inline centrifugal fans.
   3. Ceiling mounted fans.
   4. Centrifugal roof ventilator

B. Related Requirements:
   1. Section 23 05 13 - Common Motor Requirements for HVAC Equipment.
   2. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
   3. Section 23 07 13 - Duct Insulation.
   4. Section 23 33 00 - Air Duct Accessories: Backdraft dampers.
   5. Division 26 - Equipment Wiring: Electrical characteristics and wiring connections.

1.02 REFERENCE STANDARDS

A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; American Bearing Manufacturers Association, Inc.; 1990 (Reapproved 2008).

B. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings; American Bearing Manufacturers Association, Inc.; 2014


D. AMCA 204 – Balance Quality and Vibration Levels for Fans.


H. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 2011.
I. SMACNA (DCS) - HVAC Duct Construction Standards; 2005.

1.03 ACTION SUBMITTALS

A. See Division 01 - Administrative Requirements and Section 23 05 00 “HVAC and Plumbing General Requirements”, for submittal procedures.

B. Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
   1. Fan operating efficiency.
   2. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   3. Material gages and finishes, including color charts.
   4. Dampers, including housings, linkages, and operators.

C. System Data: For systems with multiple fans in parallel, provide fan curves with fans noted in a single fan curve.

D. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
   1. Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: Power, signal, and control wiring.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural supports.
   2. Roof openings.

1.05 CLOSEOUT SUBMITTALS

A. Submit under provisions of General Conditions and Division 01 as applicable.

B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

C. Manufacturer’s Installation Instructions.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Fan Belts: One set for each individual fan.
2. Lubricant: One case of each type required.

1.07 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum ten years of documented experience.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

D. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

E. UL Standards: Fans shall comply with UL 705.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.09 FIELD CONDITIONS

A. Permanent fans may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation.

B. Fans used during construction shall have all filters replaced when the Owner takes Ownership of the building.

C. Lift and support units with manufacturer's designated lifting or supporting points.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Motors:
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Speed Control: Fans shall be provided with Variable-frequency Drives (VFDs) or Electronically Commutated Motors (ECM) unless noted otherwise.

4. Enclosure Type: Totally enclosed, fan cooled (TEFC) unless noted otherwise.

D. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.

E. Performance Base: Project elevation.

F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

2.02 CENTRIFUGAL FANS

A. Manufacturers:
1. Loren Cook Company.
2. Greenheck.
4. Twin City.

B. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

C. Construction:
1. Utility Set Fans: Heavy gage steel, spot welded, adequately braced, designed to minimize turbulence with tapered spun inlet bell and shaped cut. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, lifting lugs, and accessories.
2. Plenum Fans: Fabricate without fan scroll housing, with heavy-gauge reinforced steel inlet plate with removable spun inlet cone, structural steel frame, and shaft and bearings.
3. Fan wheel: Heavy backplate, hollow die-formed, blades continuously welded at tip flange and backplate, cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
4. Factory finish before assembly to manufacturer’s standard.

D. Bearings and Drives:
1. Bearings: Heavy duty pillow block type, selfgreasing ball bearings with ABMA 9 L10 life at 40,000 hours.
2. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Direct Drive or Belt Drive.
4. Belt Drives:
5. Factory mounted, with adjustable alignment and belt tensioning.
6. Service Factor Based on Fan Motor Size: 1.5.
7. Motor Pulleys: Adjustable pitch for use with motors through 5 HP; fixed pitch for use with motors larger than 5 HP. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
8. Belt Guard: Fabricate to SMACNA Duct Construction Standards; 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

E. Accessories:
1. Outlet flange.
2. Backdraft Dampers: Gravity actuated with counterweight and interlocking blades with felt edges in steel frame installed on fan discharge.
4. Access Doors: Shaped to conform to scroll, with quick opening latches and gaskets.
5. Scroll Drain: minimum 3/4 inch steel pipe coupling welded to low point of fan scroll.
8. Disconnect Switch: Nonfusible type, with thermal-overload protection factory-mounted outside fan housing, factory wired through an internal aluminum conduit.

2.03 INLINE CENTRIFUGAL FANS

A. Manufacturers:
1. Loren Cook Company.
2. Greenheck.
3. Penn Barry.
4. Twin City.

B. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven inline centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

C. Construction:
1. Housing: Heavy gauge galvanized steel, inlet and outlet flanges, removable access panels, lifting lugs, and support bracket adaptable to floor, side wall, or ceiling mounting.
2. Direct-Drive Units: Motor mounted in airstream.
3. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
4. Fan Wheels: Aluminum, blades welded to aluminum hub.

D. Accessories:
1. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in discharge; factory set to close when fan stops.
2. Fan Guards: 1/2 by 1 inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
4. Disconnect Switch: Nonfusible type, with thermal-overload protection factory-mounted outside fan housing, factory wired through an internal aluminum conduit.

2.04 CEILING MOUNTED FANS WITH INTEGRAL GRILLE

A. Manufacturers:
   1. Panasonic.
   2. Broan.

B. Description:
   1. Fan shall be EnergyStar rated.
   2. Fan shall be UL listed for installation in a tub/shower enclosure when used with GFCI branch circuit wiring.

C. Construction:
   1. Housing: heavy-gauge galvanized steel, painted.
   2. Grille Color and Style: As selected by Architect from manufacturer's standard range.
   3. Electronically Commutated Motor (ECM).

D. Controls:
   1. Wall switch, color as selected by Architect from manufacturer's standard range.
   2. Countdown timer.
   3. Occupancy sensor.

2.05 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers:
   1. Loren Cook Company.
   2. Greenheck.
   3. Penn Barry.

B. Housing: Removable, galvanized steel, mushroom-domed top; one-piece, aluminum base with venturi inlet cone.

   1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

C. Fan Wheels: Aluminum hub and wheel.

D. Belt Drives:
   1. Resiliently mounted to housing.
   2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:
1. Disconnect Switch: Nonfusible type, with thermal-overload protection factory-mounted outside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inchmesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

3.01 INSTALLATION
A. Install in accordance with manufacturer's instructions.

B. Install centrifugal fans level and plumb.

C. Base support: Install centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.

D. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

E. Wall Support: Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.
F. Support suspended units from structure. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

G. Install fan restraining snubbers; refer to Section 23 05 48 "Vibration and Seismic Controls for HVAC." Adjust snubbers to prevent tension in flexible connectors when fan is operating.

H. Install fans with resilient electrical leads; refer to Division 26.

I. Provide sheaves required for final air balance.

J. Provide safety screen where inlet or outlet is exposed.

K. Provide backdraft dampers on discharge of exhaust fans and as indicated; refer to Section 23 33 00 "Air Duct Accessories".

L. Install units with clearances for service and maintenance.

M. Label fans according to requirements specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

3.02 CONNECTIONS

A. Install flexible connections between fan inlet and discharge ductwork; refer to Section 23 33 00 "Air Duct Accessories". Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

B. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

C. Connect wiring according to Division 26.

D. Ground spark-resistant fans according to Division 26.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   3. Verify that cleaning and adjusting are complete.
   4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   5. Adjust belt tension.
   6. Adjust damper linkages for proper damper operation.
   7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Ceiling Fans

1.02 SUBMITTALS
   A. See Section 01 33 00 – SUBMITTAL PROCEDURES

1.03 QUALITY ASSURANCE
   A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

1.04 DELIVERY, STORAGE, AND HANDLING
   A. Protect motors, shafts, blades, and bearings from weather and construction dust.
   B. Permanent fans may not be used during construction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS
   A. Modern Fan Co.
   B. Big Ass Fans.
   C. MacroAir.
   D. Aeratron.

2.02 OFFICE AND CLASSROOM SPACE FANS
   A. Modern Fan Co, or Approved equal.
   B. Oil-free permanent magnet prime mover, gearless direct drive.
   C. Airfoils: 10 TEC airfoils; Clear anodized aluminum finish.
   D. Wall Controller: Manufacturer’s LCD type.
   E. Color to be coordinated with architect prior to purchase and installation.
HMC Architects

2.03 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Coordinate exact location with drawings and Architect prior to installation.

END OF SECTION
SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Air terminal units.

B. Related Sections:
   1. Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment.

1.03 REFERENCE STANDARDS


B. ARI 880 – Air Terminals.

C. ARI 885 – Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Provide sound power level data: include schedule of discharge and radiated sound power levels at rated capacity. Sound power levels shall be in the eight octave bands from 63 Hz to 8k Hz at design static pressure.

B. Shop Drawings: For air terminal units.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Division 01:
      a. Instructions for resetting minimum and maximum air volumes.
      b. Instructions for adjusting software set points.

1.07 QUALITY ASSURANCE

A. Test and rate air performance for air pressure drop, flow performance, and acoustical performance in accordance with ARI 880 and ARI 885. Attach ARI seal to each terminal unit.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and System Start-up.”

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, “Section 6 – Heating, Ventilating, and Air Conditioning.”

2.02 TERMINAL UNITS

A. Manufacturers:
   1. Price Industries.
   2. Nailor Industries Inc.
   3. Titus.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
C. Casing: Galvanized steel, single wall.
   1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   2. Air Outlet: S-slip and drive connections.
   3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Damper shall be capable of full shut off (zero air volume).
   2. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inchwg inlet static pressure.

E. Casing Liner: Fiber-Free Foam Insulation.
   2. Insulation shall comply with UL 181 erosion, mold growth and humidity requirements in accordance with ASHRAE 62.1.
   3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

F. Airflow Sensor shall be a crossflow, differential pressure airflow device measuring total and static pressures, and mounted to the inlet valve.
   1. Sensor signal accuracy shall be plus or minus five percent throughout terminal operating range.

G. Control devices shall be provided and factory-installed by Division 25.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible,” Ch. 5, “Hangers and Supports” and with Section 23 05 29 “Hangers and Supports for HVAC Piping and Equipment.”

B. Building Attachments: Concrete inserts or structural-steel fasteners appropriate for construction materials to which hangers are being attached. Where practical, install concrete inserts before placing concrete.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.02 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.
Comply with requirements for seismic-restraint devices in Section 23 05 48 “Vibration and Seismic Controls for HVAC."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachments to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Set anchors to manufacturer’s recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.03 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.”

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.04 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Comply with requirements in Section 23 31 13 “Metal Ducts” for connecting ducts to air terminal units.
3.05 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 23 05 53 “Identification for HVAC Piping and Equipment” for equipment labels.

3.06 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.07 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION
SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Diffusers.
B. Registers/grilles.
C. Variable volume diffusers.

1.02 REFERENCE STANDARDS


1.03 SUBMITTALS

A. See Division 01 – Administrative Requirements for submittal procedures.

B. Product Data: Provide data for equipment required for this project, including materials of construction, finish, accessories furnished and mounting details. Provide performance data including throw and drop, static-pressure drop, and noise ratings. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, color, and noise level.

C. Project Record Documents: Record actual locations of air outlets and inlets.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Titus.

B. Price Industries.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.
B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.

F. Install diffusers, registers, and grilles level and plumb.

G. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

H. Install diffusers, registers, and grilles to ducts to allow service and maintenance of dampers, air extractors, and fire dampers.

I. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

J. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

K. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

END OF SECTION
SECTION 23 37 23
HVAC GRAVITY VENTILATOR

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Louvered-penthouse ventilators.
2. Roof hoods.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural[ and seismic] performance requirements and design criteria indicated.

B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
   1. Wind Loads: Determine loads based on a uniform pressure of [20 lbf/sq. ft.]<insert design wind pressure>, acting inward or outward.
   2. Wind Loads: Determine loads based on a uniform windspeed of [150 mph]

C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7].
   1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[ and the unit will be fully operational after the seismic event].”

D. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   1. Structural members to which roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

B. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.06 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5 or T-52. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.


C. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials. Use types and sizes to suit unit installation conditions.

D. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E488, conducted by a qualified independent testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187.

2.02 GENERAL

A. Manufacturers:
   1. Loren Cook Company.
   2. Greenheck.
   3. PennBarry.

B. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
C. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

D. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

E. Fabricate supports, anchorages, and accessories required for complete assembly.

F. Perform shop welding by AWS-certified procedures and personnel.

2.03 LOUVERED-PENTHOUSE VENTILATORS

A. Construction: All-welded aluminum assembly with 6-inch-deep louvers, mitered corners, and aluminum sheet roof.

B. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.060 inch for frames and 0.080 inch for blades, with corners mitered and welded.

C. Air Performance: Not more than 0.10 inch wg static pressure drop at 750 fpm free-area velocity.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
   1. Configuration: Self-flashing with built-in raised cant to suit roof type as per manufacturer’s recommendations.
   2. Overall Height: [8 inches] [12 inches] [16 inches] [18 inches].

E. Bird Screening: Aluminum, 1/2-inch-square mesh, 0.063-inch wire.

F. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

G. Accessories:
   2. [Neoprene gasket.]
   3. [Filter rack.]
   4. [Security bars.]

2.04 ROOF HOODS

A. Factory or shop fabricate according to SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible,” Figures 6-6 and 6-7.

B. Materials: [Galvanized-steel sheet, minimum 0.064-inch-thick base and 0.040-inch-thick hood] [Aluminum sheet, minimum 0.064-inch-thick base and 0.050-inch-thick hood]; suitably reinforced.

C. Insulation: 1 inch thick fiberglass.
D. Air Performance: Not more than 0.10 inch wg static pressure drop at 450 fpm hood free-area velocity, ducted intake.

E. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
   1. Configuration: Self-flashing with built-in raised cant to suit roof type as per manufacturer’s recommendations.
   2. Overall Height: [8 inches] [12 inches] [16 inches] [18 inches].

F. Bird Screening: Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

G. Insect Screening: Aluminum, 18-by-16 mesh, 0.012-inch wire.

H. Galvanized-Steel Sheet Finish:
   1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A780. Apply a conversion coating suited to the organic coating to be applied over it.
   2. Epoxy Powder Finish[ with UV protection].

I. Accessories:
   2. [Neoprene gasket.]
   3. [Washable Filter rack.]

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install gravity ventilators with clearances for service and maintenance.

C. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 for sealants applied during installation.

E. Label gravity ventilators according to requirements specified in Section 23 05 53 “Identification for HVAC Piping and Equipment.”

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
G. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.02 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 23 31 00 “HVAC Metal Ducts”. Drawings indicate general arrangement of ducts and duct accessories.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION
SECTION 23 41 00
PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary
      Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section Includes:
      1. Flat panel filters.
      2. Pleated panel filters.
      3. Non-supported bag filters.
      4. Rigid cell box filters.
      5. Bulk media.
      6. Filter gauges.

1.03 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated. Include dimensions; operating
      characteristics; required clearances and access; rated flow capacity, including initial and
      final pressure drop at rated airflow; efficiency and test method; fire classification;
      furnished specialties; and accessories for each model indicated.

   B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and
      attachments to other work.
      1. Show filter rack assembly, dimensions, materials, and methods of assembly of
         components.
      2. Include setting drawings, templates, and requirements for installing anchor bolts
         and anchorages.
      3. Include diagram for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS
   A. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For each type of filter and rack to include in
      emergency, operation, and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS
   A. Furnish extra materials that match products installed and that are packaged with
      protective covering for storage and identified with labels describing contents.
      1. Provide one complete set(s) of filters for each filter bank.
PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:
   1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
   2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames complying with UL 900.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AAF International.
      b. Camfil Farr.
      c. Flanders Corporation.
      d. Purafil, Inc.

B. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
   1. Media shall be coated with an antimicrobial agent.

C. Filter-Media Frame: Cardboard with perforated metal retainer sealed or bonded to the media.

D. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.03 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames complying with UL 900.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AAF International.
      b. Camfil Farr.
      c. Flanders Corporation.
      d. Purafil, Inc.
B. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
   1. Media shall be coated with an antimicrobial agent.
   2. Separators shall be bonded to the media to maintain pleat configuration.
   3. Welded-wire grid shall be on downstream side to maintain pleat.
   4. Media shall be bonded to frame to prevent air bypass.
   5. Support members on upstream and downstream sides to maintain pleat spacing.

C. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

D. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.04 NON-SUPPORTED BAG FILTERS

A. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames complying with UL 900.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AAF International.
      b. Camfil Farr.
      c. Flanders Corporation.
      d. Purafil, Inc.

B. Media: Synthetic material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   1. Media shall be coated with an antimicrobial agent.

C. Filter-Media Frame: Galvanized steel.

D. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.05 RIGID CELL BOX FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames complying with UL 900.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AAF International.
      b. Camfil Farr.
      c. Flanders Corporation.
      d. Purafil, Inc.

B. Filter Unit Class: UL 900.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   1. Media shall be coated with an antimicrobial agent.
D. Filter-Media Frames: Galvanized steel.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.06 BULK MEDIA

A. Description: Air-filter media, factory custom cut or rolled complying with UL 900.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. AAF International.
      b. Camfil Farr.
      c. Flanders Corporation.
      d. Purafil, Inc.

B. Media: Synthetic, in a roll.

C. Capacities and Characteristics:
   1. Thickness or Depth: 1 inches.
   2. Maximum or Rated Face Velocity: 800 fpm.
   3. Arrestance: 85 percent when tested according to ASHRAE 52.2.

2.07 FILTER GAUGES

A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AirGuard; Clarcor Air Filtration Products, Inc.
      b. Dwyer Instruments, Inc.
   2. Diameter: 4-1/2 inches.
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
   5. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: .
   6. Connection to control system, refer to Division 25.

B. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:
   1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gauge for each filter bank.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary or bulk media filters used during construction and testing with new, clean filters.

F. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position.

G. Coordinate filter installations with duct and air-handling-unit installations.

3.02 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:
   1. Test for leakage of unfiltered air while system is operating.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.03 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION
PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. The requirements of the General Conditions, Supplementary Conditions, And Division 1, General Requirements, apply to the Work of this section.

1.02 SUMMARY
   A. Section includes rooftop dedicated outside air system units (DOAS) with associated components and accessories.

1.03 RELATED REQUIREMENTS
   A. Division 22 – condensate drains.
   B. Section 230513 – Common Motor Requirements for HVAC Equipment.
   C. Section 230548 – Vibration and Seismic Controls for HVAC Piping and Equipment.
   D. Section 233300 – Air Duct Accessories: Flexible duct connections.
   E. Section 233400 – HVAC Fans.
   F. Division 26 – Equipment Wiring: Electrical characteristics and wiring connections.

1.04 REFERENCE STANDARDS
   A. AFBMA 9 – Load Ratings and Fatigues Life for Ball Bearings
   B. AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings
   C. AMCA 99 – Standards Handbook
   D. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
   E. AMCA 300 – Test Code for Sound Rating Air Moving Devices
   F. AMCA 301 – Method of Publishing Sound Ratings for Air Moving Devices
   G. AMCA 500 – Test Methods for Louver, Dampers, and Shutters
   H. AHRI 410 – Forced-Circulation Air-Cooling and Air-Heating Coils
   I. AHRI 430 – Central Station Air Handling Units
   J. AHRI 435 – Application of Central Station Air Handling Units
ADDENDUM NO. 1

5036004
PACKAGED ROOFTOP-AIR HANDLING UNITS
D-4014 Diablo Valley College P/K Complex

HMC Architects

K. AHRI 610 – Central System Humidifiers
L. NEMA MG1 – Motors and Generators
M. NFPA 70 – National Electrical Code
N. SMACNA – HVAC Duct Construction Standards – Metal and Flexible
O. UL 900 – Test Performance of Air Filter Units
P. VFD and options shall be ULTM 508 listed.
Q. NEMA 12 enclosed VFD shall be ULTM approved for mounting in conditioned air ducts and plenums.

1.05 ACTION SUBMITTALS

A. Submit under provisions of General Conditions and Division 01 as applicable.
B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.
C. Product Data:
   1. Provide literature, which indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, electrical characteristics and connection requirements.
   2. Provide data on filter media, filter performance data, filter assembly, and filter frames.
   3. Provide fan curves with specified operating point clearly plotted.
   4. Submit sound power level data for fan unit outlet, inlet and casing radiated at rated capacity and specified pressure.
   5. Submit electrical requirements for power supply including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
   6. Submit performance and vibration test results of the fan for review prior to any air handling unit shipment to the jobsite.

1.06 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Structural members to which units will be attached.
   2. Roof openings.
   3. Roof curbs and flashing.
ADDENDUM NO. 1

B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in “Performance Requirements” Article and in Section 23 05 48 “Vibration and Seismic Controls for HVAC.”
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Seismic Qualification Certificates: For units, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   4. Restraint of internal components, including fans, coils, and refrigeration components.

D. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

A. Submit under provisions of General Conditions and Division 01 as applicable.

B. Operation and Maintenance Data: For units to include in emergency, operation, and maintenance manuals. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists and wiring diagrams.

C. Manufacturer’s Installation Instructions.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Extra Fan Belts: One set for each belt-driven fan.
   2. Filters: One set of filters for each unit.

1.09 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five (5) years documented experience, which issues complete catalog data on total product.

1.10 WARRANTY

A. See Division 01 – Closeout procedures, for additional warranty requirements.
B. Provide manufacturer’s warranty for period of 18 months from date of project substantial completion. Warranty to include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory-authorized on-site service.
   1. Warranty Period for Control Boards: Manufacturer’s standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Carrier

B. Daikin

C. Johnson

D. Trane

E. York

2.02 GENERAL REQUIREMENTS


B. AMCA Compliance:
   1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
   2. Damper leakage tested in accordance with AMCA 500-D.
   3. Operating Limits: Classify according to AMCA 99.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Unit shall be configured for Dedicated Outdoor Air System (DOAS) or Makeup Air (MAU) operation.

2.03 UNIT BASE

A. Each unit shall be constructed on a base fabricated from ASTM A36 welded structural steel channel. Tubular or formed metal channel bases are not acceptable.
   1. Heavy removable lifting lugs shall be added to the perimeter channel along the longest length of the unit.
   2. The unit floor shall be fabricated of 14-gauge welded hot rolled galvanized steel sheets. The floor shall be supported by structural and minimum 12-gauge formed galvanized steel members. Max spacing of floor support shall be 24” centers. These formed members shall be welded to other members for maximum strength. Floor skin shall be supplied with standing seams design and drive cleats to maintain water and airtight seal. The flooring shall be spot welded to the members below –no penetrations thru the floor skin shall be acceptable. Welds shall be below the floor and spaced no greater than 6” on center.
3. Fans, coils and major components shall be supported with structural steel members.

2.04 UNIT HOUSING

A. General Fabrication Requirements for Housing: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight for R-13 performance. Insulation:
   1. Thickness: 4 inches.
   2. Density: 3 lbs per cubic foot.
   4. Construction: cover all walls, ceilings, and under floors.
   5. Shall meet NFPA 90A smoke and flame spread requirements.
   6. There shall be no raw edges of insulation exposed to the airstream.

C. Exterior Casing Material: Galvanized steel with factory-painted polyester resin finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Inside Casing: G-90-coated galvanized steel. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Drain pans shall be constructed from 16-gauge, 304 stainless steel. The drain pan shall be insulated with 2.0", 1.5 pcf density insulation to prevent condensation under the drain pan. Insulation shall be protected with an 18-gauge galvanized steel liner. Drain pans must be sized such that the entire coil, including headers and return bends, are inside the drain pan. Drain pans must slope in two directions so there is no standing water in drain pan. Stainless steel condensate connection shall be provided on one side of the unit. Coils shall be supported on 10 gauge stainless steel members to prevent immersion of the coil in condensate and allow for complete cleaning of drainpan beneath the coils.

F. After final assembly the unit exterior shall be coated with an industrial grade, high solids, and polyurethane paint.

G. Provide factory rain hoods at all outdoor air inlets. Provide birdscreen.

2.05 FANS

A. Type: Single width, single inlet, centrifugal fan. Refer to Section 23 34 00 “HVAC Fans”.

B. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.

C. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.
D. Each fan shall be individually isolated. Multiple fans mounted on a single rigid assembly shall not be acceptable. Each fan shall be mounted on a welded isolation frame constructed of heavy gage formed steel and structural tubing. Refer to 23 05 48 “Vibration and Seismic Controls for HVAC”.

E. The fan diameter and width shall be sized to optimize fan performance as indicated on the equipment schedule. Design point of operation should not exceed 90% of peak static pressure.

F. The fan shaft shall be sized not to exceed 75% of the first critical speed for maximum RPM of Class specified. The critical speed will refer to the top of the speed range of the fans’ AMCA class. The lateral static deflection shall not exceed 0.003” per foot of the length of the shaft. Fans shall be balanced to ISO standard G6.3.

2.06 MOTORS

A. Refer to Section 23 05 13 “Common Motor Requirements for HVAC Equipment”.

B. Motors shall be driven by Variable-frequency Drives (VFDs) or Electronically Commutated (ECM).

1. Refer to Section 23 05 14 “Variable-Frequency Drives”.

2.07 COILS

A. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.

B. Fabrication:

1. Type: Plate fin extended surface.
2. Tubes: 5/8 inch OD seamless copper with 0.020 inch minimum wall thickness, expanded into the fin collars to provide a permanent mechanical bond.
3. Fins: 0.008 inch thick aluminum fins.
4. Return bends: 0.025” wall thickness individually replaceable on both sides of the coil.

C. Hydronic Coils:

1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.

2.08 FILTERS

A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2.

2.09 DAMPERS

A. Dampers shall be supplied with low leak extruded aluminum airfoil blades. Blades shall be supplied with rubber edge seals and stainless steel arc end seals. Rubber edge seals shall be backed by the damper blade to assure a positive seal in the closed position. Dampers shall be provided with nylon bearings within extruded openings.

B. Damper leakage shall not exceed 6 CFM/ft² at 5.0” of static pressure. Leakage testing shall be in accordance with AMCA Standard 500, Figure 5.5. Test results must be from independent testing laboratory.

2.10 ELECTRICAL REQUIREMENTS

A. Provide unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

B. Provide single point power connection.
   1. Exception: duplex, 115v convenience outlet with 15A overcurrent protection.

2.11 CONTROLS

A. Basic Unit Controls:
   1. Unit-Mounted Annunciator Panel for Each Unit:
      a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
      b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
      c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

B. Interface Requirements for HVAC Instrumentation and Control System:
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
   3. Provide BACnet compatible interface for central HVAC control workstation for the following:
      a. Adjusting set points.
      b. Monitoring supply fan start, stop, and operation.
      c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature.
      d. Monitoring occupied and unoccupied operations.
      e. Monitoring constant and variable motor loads.
      f. Monitoring variable speed controller operation.
      g. Monitoring cooling / heating load.
      h. Monitoring air-distribution static pressure and ventilation air volume.

2.12 ACCESSORIES

A. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
B. Safeties:  
1. Smoke detector.

C. Outdoor air intake weather hood.

D. Service Lights and Switch: Factory installed in fan and coil sections with weatherproof cover.

E. Roof Curb:  
1. Prefabricated mounting curb shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling and condensing sections.
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
3. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 “Vibration and Seismic Controls for HVAC” for wind-load requirements.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

A. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish. All fans must be periodically rotated during storage period per manufacturer recommendation. Unit is to be alcohol wiped before shipment.

3.02 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of units.

B. Examine roughing-in for units to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Equipment Mounting;  
1. Roof Curb: Install on roof structure or concrete base, level and secure. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07. Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
2. Install units level on structural curbs. Coordinate penetrations and flashing with construction. Secure units to structural support with anchor bolts.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 05 48 “Vibration and Seismic Controls for HVAC.”

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.04 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain. Refer to Plumbing Drawings.

B. Install piping adjacent to units to allow service and maintenance.

C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
   2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   3. Connect supply ducts to units with flexible duct connectors specified in Section 23 33 00 “Air Duct Accessories.”
   4. Install return-air duct continuously through roof structure.

D. Power connections by Division 26.
   1. Connect convenience outlet to separate circuit as per NEC.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing units and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.06 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated, and fan has been test run under observation.

3.07 INSTALLATION AND START UP

A. Complete installation and startup checks according to manufacturer’s written instructions.
SECTION 23 82 19
FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Refer to Section 23 00 00 “HVAC General Requirements” for project conditions.

1.2 SUMMARY

A. Section Includes:
   1. Hydronic fan coil units and accessories.

B. Related Sections:
   1. Division 22: Condensate drain piping.
   2. Section 23 00 00 “HVAC General Requirements” for project conditions.
   3. Section 23 21 13 “Hydronic Piping”
   4. Division 26: Power connections to equipment.

1.3 ACTION SUBMITTALS

A. See Division 01 and Section 23 00 00 “HVAC General Requirements” for submittal procedures.

B. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

C. Shop Drawings:
   1. Include details of equipment assemblies, dimensions, weights, loads, required clearances, construction details, electrical characteristics, and connection requirements.
   2. Include diagrams for power, signal, and control wiring.
   3. Contractor shall include a copy of the design installation diagrams as a part of their submittal and either sign off on agreeing to all aspects of the intent or provide a letter to the same effect.

D. Controls Information:
   1. Contractor shall review the control diagrams, sequences of operation, and points lists and confirm manufacturer’s hardware and programming will allow:
      a. Sequences of operation to be implemented without changes.
      b. System integration via hardwired, BACnet, other platform communication.
      c. Read / Write points integration.
2. Contractor shall include a copy of the design control diagrams, sequences of operation, and points list as a part of their submittal and either sign off on agreeing to all aspects of the control intent or provide a letter to the same effect.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details on which the following items are shown and coordinated with each other—using input from installers of the items involved:
1. Suspended ceiling components.
2. Structural members to which fan coil units will be attached.
3. Method of attaching hangers to building structure.
4. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. <Insert item>
5. Perimeter moldings.

B. Seismic Certificates: For fan coil units, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals. Include instructions for lubrication, motor, drive replacement, and spare parts list and wiring diagram. Provide maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan Coil Unit Filters: Furnish one set spare filters for each filter installed.
2. Fan Belts: Furnish one extra set for each belt driven fan.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and Startup.”
C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 – “Heating, Ventilating, and Air-Conditioning.”

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake where applicable.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: [Five] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 HYDRONIC FAN COIL UNITS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. ENVIRO-TEC; by Johnson Controls, Inc.
   2. Nailor.
   4. Titus.
   5. Tuttle and Bailey.

B. Coil Section Insulation: [1/2-inch-] [1-inch-] thick, [coated glass fiber] [foil-covered, closed-cell foam] [matte-finish, closed-cell foam] complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
   1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
   2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Coil Section Insulation: Insulate coil section according to Section 23 07 16 “HVAC Equipment Insulation.”
1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.

2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. [Main and Auxiliary] Drain Pans: [Plastic] [Stainless steel] [Insulated galvanized steel with plastic liner]. Fabricate pans and drain connections to comply with ASHRAE 62.1. [Drain pans shall be removable.]

E. Chassis: Galvanized steel where exposed to moisture, with powder-coat finish and removable access panel. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with [powder-coat finish in manufacturer's standard paint color] [powder-coat finish in manufacturer's custom paint color as selected by Architect].
   1. Vertical Unit Front Panels: Removable, steel, with steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with cast-aluminum discharge grilles.
   3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's [standard] [custom] colors. Return grille shall provide maintenance access to fan coil unit.
   4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Outdoor-Air Wall Box: Minimum 0.1265-inch- thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
   1. Louver Configuration: [Horizontal] [Vertical], rain-resistant louver.
   2. Louver Material: [Aluminum] [Steel].
   5. Finish: Anodized aluminum, color as selected by Architect from manufacturer's [standard] [custom] colors.

H. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [electronic], [two-position] [modulating] actuators.

I. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
   1. Pleated Cotton-Polyester Media.

J. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.
   1. Coating Requirements: Where indicated on the drawings or elsewhere in the specifications provide a coil coating that meets the following minimum requirements.
      a. Manufacturers:
         1) ElectroFin E-Coat
2) BlyGold PoluAl
   a. The entire coil shall be coated by a certified licensed applicator or equal coating.
   b. Product manufacturer must be able to document the successful completion of accelerated product testing of a minimum 3000 hours in both salt spray (ASTM B117) and acid salt spray tests (ASTM G85).
   c. Manufacturer shall provide a 3 year conditional warranty for the coating applied on aluminum-finned, copper tube coils.
   d. The product application process shall include a chromate-free conversion layer applied to the coil that achieves total coverage and penetration. An aluminum-impregnated polyurethane topcoat shall then be applied that ensures total penetration and coverage without bridging or significantly affecting the heat transfer ability of the coil.
   e. The total dry film thickness of the topcoat shall be 20 to 25 microns.


L. Fan and Motor Board: Removable.
   1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   3. Wiring Termination: Connect motor to chassis wiring with plug connection.

M. Factory, Hydronic Piping Package: [ASTM B88, Type L] [ASTM B88, Type M] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Working pressure of accessories and specialties shall be no less than the associated hydronic system.
   1. Two-way, modulating control valve for dual-temperature coil.
   2. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations. Minimum Diameter: Equal to fan coil unit connection size.
   3. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; blowout-proof stem.
   4. Calibrated-Orifice Balancing Valves: Bronze body, ball type; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
   5. Automatic Flow-Control Valve: Brass or ferrous-metal body; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent.
   6. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
8. Risers: Copper pipe with hose and ball valve for system flushing.

N. Control devices and operational sequences are specified in Division 25.

O. Basic Unit Controls:
1. Control voltage transformer.
2. [Wall-mounting] [Unit-mounted] thermostat with the following features:
   b. Fan on-auto switch.
   c. Fan-speed switch.
   e. Adjustable deadband.
   f. [Concealed] [Exposed] set point.
   g. [Concealed] [Exposed] indication.
   h. [Degree F] [Degree C] indication.
3. [Wall-mounting] [Unit-mounted] humidistat.
   a. [Concealed] [Exposed] set point.
   b. [Concealed] [Exposed] indication.
4. [Wall-mounting] [Unit-mounted] temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.
   a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
   b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

P. DDC Terminal Controller:
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied-Period-Override Operation: [Two] <Insert number> hours.
3. Unit Supply-Air Fan Operation:
   a. Occupied Periods: Fan runs continuously.
   b. Unoccupied Periods: Fan cycles to maintain room setback temperature.
4. Hydronic-Cooling-Coil Operation:
   a. Occupied Periods: Modulate control valve to maintain room temperature.
   b. Unoccupied Periods: Close control valve.
5. Reheat-Coil Operation:
   a. Humidity Control for Occupied Periods:
      1) Humidistat [modulates control valve] [energizes electric-resistance coil] to provide heating and meet space temperature setpoint.
   b. Humidity Control for Unoccupied Periods: [Close control valve] [De-energize].
6. Outdoor-Air Damper Operation:
   a. Occupied Periods: Open damper to fixed position for [25] <Insert number> percent outdoor air.
   b. Unoccupied periods: Close damper.
7. Outdoor-Air Damper Operation:
   a. Occupied Periods:
      1) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air...
damper to maintain room temperature (outdoor-air economizer). If 
room temperature is below thermostat set point, position damper to 
fixed minimum position.

2) Outdoor-Air Temperature above Room Temperature: Position damper 
to fixed minimum position for [25] <Insert number> percent outdoor 
air.

b. Unoccupied Periods: Close damper.

8. Outdoor-Air Damper Operation (Enthalpy Based):
   a. Occupied Periods:
      1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is 
         above room-temperature set point, modulate outdoor-air damper to 
         maintain room temperature (outdoor-air economizer). If room 
         temperature is below set point, position damper to fixed minimum 
         position for [25] <Insert number> percent outdoor air.

      2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed 
         minimum position for [25] <Insert number> percent outdoor air.

   b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

9. Controller shall have volatile-memory backup.

Q. Interface with DDC System for HVAC Requirements:
   1. Interface relay for scheduled operation.
   2. Interface relay to provide indication of fault at the central workstation.
   3. Provide BACnet interface for central DDC system for HVAC workstation for the 
      following functions:
      a. Adjust set points.
      b. Fan coil unit start, stop, and operating status.
      c. Data inquiry, including [outdoor-air damper position, ]supply- and room-
         air temperature] and humidity]
      d. Occupied and unoccupied schedules.

R. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with 
requirements for installation tolerances and other conditions affecting performance of the 
Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations 
before fan coil unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.
C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor unless noted otherwise.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   1. Install piping adjacent to machine to allow service and maintenance.
   2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
   3. Connect condensate drain to indirect waste.
      a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to ducted fan coil units with flexible duct connectors specified in Section 23 33 00 “Air Duct Accessories.” Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26.

D. Connect wiring according to Division 26.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections[ with the assistance of a factory-authorized service representative]:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.
3.6 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION
SECTION 23 83 00
RADIANT FLOORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section Includes
      1. Radiant heating and/or cooling piping, including pipes, fittings, and piping specialties.

1.03 DEFINITIONS
   A. CWP: Cold working pressure.
   B. PE: Polyethylene.
   C. PEX: Crosslinked polyethylene.
   D. PEX-a: Engel-method crosslinked polyethylene.
   E. AL/PEX: Aluminum/crosslinked polyethylene.
   F. PTFE: Polytetrafluoroethylene plastic.

1.04 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
   B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls including temperature sensors, and support assemblies, and their attachments to building structure.
      1. Shop Drawing Scale: 1/4 inch = 1 foot.
   C. Operation and Maintenance Data:
      1. Submit operation and maintenance data under provisions of Division 01 Section “General Requirements”.
   D. Controls Information:
      1. Contractor shall review the control diagrams, sequences of operation, and points lists and confirm manufacturer's hardware and programming will allow:
         a. Sequences of operation to be implemented without changes.
b. System integration via hardwired, BACnet, other platform communication.
c. Read / Write points integration.
2. Contractor shall include a copy of the design control diagrams, sequences of operation, and points list as a part of their submittal and either sign off on agreeing to all aspects of the control intent or provide a letter to the same effect.

1.05 INFORMATIONAL SUBMITTALS
A. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For radiant heating and/or cooling piping valves and equipment to include in operation and maintenance manuals.

1.07 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Extra Fan Belts: One set for each belt-driven fan.
   2. Filters: One set of filters for each unit.

1.08 QUALITY ASSURANCE
A. Installer Qualifications: Work shall be performed by a contractor with at least two years of experience with radiant floor installations.
B. ASTM International
   4. ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing

1.09 DELIVERY, STORAGE, AND HANDLING
A. For all radiant heating and/or cooling piping:
   1. The cross-linked polyethylene (PEX) tubing shall be shipped to the job site on truck or in such a manner to protect the tubing. The tubing and fittings shall be unloaded with care.
   2. PEX tubing and fittings shall be stored in a flat, dry, well-ventilated location. Normal care in handling shall be exercised to avoid abuse of the tubing. The tubing and fittings shall not be thrown or dropped on the ground, walked on or dragged.
3. Do not use adhesive tape on the tubing or leave tubing exposed to direct sunlight for extended periods of time (two weeks maximum, or manufacturer’s recommendations, whichever is more stringent).

B. For preassembled radiant piping products:
1. All completed radiant assemblies shall be pressure tested prior to shipment and left under a static internal pressure of no greater than 20 psig or less than 5 psig until delivered at the construction site. Each pressurized assembly shall be inspected for pressure retention upon receipt at the construction site.

1.10 WARRANTY

A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.

B. Manufacturer’s Warranty: Submit, for Owner’s acceptance, manufacturer’s standard warranty document executed by authorized company official. Manufacturer’s warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.

C. Manufacturer’s Warranty: Warranty Period for PEX Tubing: 30-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion when installed by an Uponor factory-trained contractor.

D. Warranty Period for Manifolds and Fittings: five-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion when installed by a factory-trained contractor.

E. Warranty Period for Controls and Electrical Components: two-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion when installed by a factory-trained contractor.

F. If a factory-trained contractor does not install the system, then a 5 years parts and labor warranty shall be provided.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. All piping, mats, and other components shall be provided by the same manufacturer.

B. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Uponor.
   2. Rehau.
   3. Viega LLC.

2.02 PEX PIPE AND FITTINGS

A. Pipe Material: PEX plastic according to ASTM F876.
B. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum $6.2 \times 10^{-9}$ lb per cu ft per day at 104 deg F according to DIN 4726.

C. Fittings: ASTM F1807, metal insert and copper crimp rings.

D. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.

E. Tubing will have 6-month UV protection.

F. Certified to ASTM E84 and ULC S102.2 Flame Spread (FS)/Smoke Developed (SD) (25/50).

2.03 RADIANT HEATING/COOLING PIPING PREASSEMBLED MAT

A. Both preassembled mat products outlined in this subsection and conventional radiant installation outlined above in “PEX Pipe and Fittings” are acceptable and may be used in tandem.

B. Material: PEX or PEX-a.

C. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third-party agency.

D. Pressure Ratings: Standards Grade hydrostatic design and pressure ratings as issued by the Plastics Pipe Institute (PPI), a Division of the Society of the Plastics Industry (SPI).
   1. 200 deg F at 100 psig, 180 deg F at 125 psig, 140 deg F at 160 psig, 73 deg F at 200 psig.

E. Show compliance with ASTM E119 and ANSI/UL 263 through certification listings through UL.

F. UL Design No. K913 – 2-hour concrete floor/ceiling assemblies
   1. Barrier Tubing: PEX-a.:
      a. Tubing features an oxygen-diffusion barrier.
      b. Nominal Inside Diameter: Provide tubing with nominal inside diameter in accordance with ASTM F876, as indicated in the system design.
   2. Mats shall come with support strips at every 4 ft to assist in straightening and stabilizing.

G. Header
   1. In-slab reverse-return header assembly
   2. Reverse-return in-slab manifold that permits a self-balancing flow within each circuit with equal distance of piping and tubing lengths.
   3. In-slab manifold shall contain fittings that meet F1960 Cold-expansion Fittings with PEX Reinforcing Rings.
   4. Fittings:
      a. Shall meet the requirements of ASTM F877.
      c. Polymer Fittings: Radel®R polyphenylsulfone or Acudel®1 modified polyphenylsulfone, which are corrosion resistant; or equal.
d. Connect to supply and return distribution piping
   1) Connections use F1960 fittings.
5. In-slab manifolds reverse-return header assemblies contain left and right-hand line
   extensions to permit a central location for connection mats to supply and return
   distribution piping.
6. Support Strips
   a. Acetal polymer support strips that are spaced every four feet in the mat
      length.
   b. Fastened to mat tubing with plastic zip ties.
   c. Open spacing between adjacent tubes permits fastening to rebar, metal
      grids, or metal meshes.
   d. Pre-drilled holes allow stakes to fasten the space guards to slab on grade
      installations.

2.04 DISTRIBUTION MANIFOLDS

A. Manifold: brass or stainless steel.

B. Main Shutoff Valves:
   1. Factory installed on supply and return connections.
   2. Two or Three-piece body.
   3. Body: Brass or bronze.
   4. Ball: Chrome-plated bronze.
   5. Seals: PTFE.
   7. Maximum Operating Temperature: 225 deg F.
   8. Meet requirements of Section 23 0523.
   9. Supply valve shall have integrated strainer/filter. The filter ball shall have isolation
      within the valve to allow easy cleaning of filter.

C. Manual Air Vents:
   1. Body: Bronze.
   2. Internal Parts: Nonferrous.
   3. Operator: Key furnished with valve, or screwdriver bit.
   4. Inlet Connection: NPS 1/2.
   7. Maximum Operating Temperature: 225 deg F.
   8. Meet requirements of Section 23 2116.

D. Balancing Valves:
   1. Body: Stainless steel or bronze, ball or plug, or globe cartridge type.
   2. Ball or Plug: Brass or stainless steel.
   4. Seat: PTFE.
   5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top
      of valve.
   6. Differential Pressure Gage Connections: Integral seals for portable meter to
      measure loss across calibrated orifice.
   7. Handle Style: Lever or knob, with memory stop to retain set position if used for
      shutoff.
8. CWP Rating: 125 psig.
9. Maximum Operating Temperature: 250 deg F.
10. Meet requirements of Section 23 0523.

E. Zone Control Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
7. Maximum Operating Temperature: 250 deg F.
8. Meet requirements of Section 23 0523.

F. Thermometers:
1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, 2-inch diameter; smaller diameter may be accepted with documented approval of Mechanical Engineer.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, connecting element and pointer.
9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
10. Accuracy: ± 1 percent of range or ± 1 scale Division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

2.05 PIPING ATTACHMENT

A. Cable Ties:
1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Galvanized steel alloy wire ties, minimum 6-inch
4. Tensile Strength: 20 lbf, minimum.
5. Temperature Range: -40 to 185 deg F.

B. Floor Mounting Staples:
1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
3. Width: Minimum, wider than tubing.

C. Floor Mounting Clamps:
1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
3. Width: Minimum, wider than tubing.
D. Floor Mounting Tracks:
   1. Aluminum or plastic channel track with smooth finish and no sharp edges.
   3. Slot Width: Snap fit to hold tubing.
   4. Slot Spacing: 3 inch intervals.

2.06 SLAB-EMBEDDED TEMPERATURE SENSORS

A. General
   1. Slab-embedded temperature sensor shall consist of a temperature sensor element in a sensor receptacle, designed and installed to facilitate replacement of sensor element.
   2. Sensor assembly shall be embedded in concrete floor or ceiling in locations shown on Contract Drawing mechanical floor plans, and as described in Part 3 of this Section.
   3. Slab-embedded temperature sensor shall measure the temperature of the thermal mass into which it is installed for monitoring and control of radiant systems.

B. Manufacturers (alphabetical order)
   1. Automated Logic Corp
   2. Building Automation Products Inc
   3. Kele Associates
   4. Mamac
   5. Or equal

C. Sensor Element
   1. Sensor
      a. Thermistor or RTD type sensor, suitable for temperatures being sensed.
      b. Accuracy as required to satisfy Division 25 specifications.
         1) Inaccuracy due to wire resistance shall in no case exceed 0.5 deg F. Select wire gauge and/or provide transmitter if necessary to meet this requirement.
      c. Drift shall not exceed 0.3 deg F per year.
      d. Sensor shall not require recalibration for at least five years.
   2. Temperature Transmitter
      a. Provide when required for compatibility with controller or to meet specified accuracy.
      b. Output: 4-20mA linearly across specified temperature range.
      c. Include zero and span adjustment.
      d. Accuracy: ±0.1 deg F. across sensor range.
   3. Sensor shall be encapsulated in 1/4 inch stainless steel probe and shall fit snugly into thermowell.
   4. Select sensor and thermowell length so that at least 1" 1 inch of sensor probe sticks out of thermowell when sensor is fully inserted, so that it can easily be removed.
   5. Sensor shall terminate in bare wires (no enclosure).
   6. Sensor probe length shall be such that it can be easily installed in and removed from receptacle.

D. Sensor Receptacle
1. The sensor receptacle shall be a box with a single-piece machined thermowell securely attached on one side, a conduit connection on the other, and a 2-wire terminal block attached to the interior. See detail included with Contract Drawing control schematics.

2. Each sensor receptacle box shall be dedicated to that sensor. Do not share box with other signal or power wiring.

3. Box shall be metal, designed for flush installation on or below grade in poured concrete floor or ceiling slab, with a solid cover (no slots). Cover shall secure with screw or latch and shall include watertight gasket, UL scrub water tested. Color/finish shall match final finish of surface where installed.

4. Receptacle and cover shall be large enough to accommodate removal and installation of sensor probe after box is installed, with space to coil extra wire.

5. Assembly of receptacle shall be the responsibility of the DDC Contractor.

PART 3 - EXECUTION

3.01 HOLD AND INSPECTION

A. Refer to provisions of Division 01 Section “Special Procedures” for hold points for inspection, witnessing testing, etc.

3.02 EXAMINATION

A. Examine surfaces and substrates to receive radiant piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. Ensure that surfaces and pipes in contact with radiant heating and/or cooling piping are free of burrs and sharp protrusions.
   2. Ensure that surfaces and substrates are level and plumb.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

B. Install radiant heating and/or cooling piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

C. Before concrete pour: If piping is sliced, punctured, or otherwise damaged, repair it per manufacturer’s recommendations and notify the Engineer of Record. If a loop is damaged more than once, replace entire loop.

D. After concrete pour: Contractor shall take extreme care not to puncture tubing and coordinate with other trades to notify them that the concrete slab contains radiant tubing. If piping is sliced, punctured, or otherwise damaged, repair it per manufacturer’s recommendations and notify the Engineer of Record.
E. Connect radiant piping to manifold in a reverse-return arrangement.

F. Do not bend pipes in radii smaller than manufacturer’s minimum bend radius dimensions.

G. Ensure tube lengths do not exceed 500 linear feet per loop (including leaders to manifolds) for 5/8 inch diameter tubing. The longest tube lengths on one manifold shall be within 5% of the lengths of the other tubes on the same manifold.

H. Record actual tubing loop lengths on the record set of drawings.

I. Sealing: Prevent entry of foreign matter into any part of the piping by sealing openings during construction.

J. Flushing: flush and clean piping and floor tubing before connection. When flushing main system, provide temporary bypass so that main system is not flushed through radiant tubing.

K. Install insulated flanges or unions at points of connection between dissimilar metals.

L. Tubing shall not be installed closer than 6 inches to any exterior walls, interior wall plates, water closets, or other fixtures which are anchored to the floor with metal fasteners or driven into the concrete.

M. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Division 08. Do not locate manifolds in rated walls or electrical room walls.

N. Fire- and Smoke-BARRIER Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07.

O. Piping in Interior Reinforced-Concrete Floors:
1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties. Where location of tubing is between rebar layers, provide 6 inches on center (o.c.) wire mesh or equal raised to proper height with chairs. Refer to drawing for tube installation detail.
2. Space cable ties a maximum of 18 inches o.c. and at center of turns or bends.
3. Maintain 2 inches minimum cover or as shown on Drawings, whichever is greater.
4. Install a sleeve of 3/8 inches thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40 psig pressure in piping during concrete placement and continue for 24 hours after placement.

P. Piping in Level Fill Concrete Floors (Not Reinforced):
1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples. Where location of tubing is between rebar layers, provide 6 inches o.c. wire mesh or equal raised to proper height with chairs. Refer to drawing for tube installation detail.
2. Space tracks, clamps, or staples a maximum of 18 inches o.c. and at center of turns or bends.
3. Maintain 3/4 inches minimum cover or as shown on Drawings, whichever is greater.
4. Install a sleeve of 3/8 inches thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40 psig pressure in piping during the concrete pour and continue for 24 hours during curing.

Q. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

R. Slab-Embedded Temperature Sensors
   1. General
      a. Install slab-embedded temperature sensor in locations shown on Contract Document mechanical plans.
      b. Sensor shall be installed near top surface of floor slab, or near bottom surface of ceiling slab, as indicated on drawings. For purposes of this Article, sensor “depth” refers to the shortest distance between the exterior of the assembly thermowell and the nearest slab surface.
      c. Sensor shall be positioned equidistant between lengths of embedded hydronic tubing as shown in the detail.
      d. Sensor shall be installed a minimum of 1 inch deep and no deeper than the hydronic tubing embedded in the slab.
      e. Do not install sensor assembly where it will be covered by permanently installed furniture or fixtures.
      f. If installation locations shown on plans are not feasible or are not clear, Controls Contractor shall notify Engineer of Record before commencing installation.
   2. Sensor Receptacle Construction
      a. Securely attach thermowell to end of receptacle box. Position thermowell vertically so that it will be at the correct depth when sensor receptacle is installed in slab.
      b. Inside receptacle box, securely install two-wire terminal block, positioned for ready access.
      c. Connect conduit to other end of receptacle box.
      d. Conduit shall extend from box to wall or other interstitial space from which signal wiring can run to controller.
      e. Verify that sensor can be readily inserted and removed from receptacle box before installing in slab.
   3. Sensor Receptacle Installation
      a. Install receptacle so that it will be flush with finished floor.
      b. Locate receptacle so that thermowell is correctly positioned relative to hydronic tubing layout.
      c. Secure conduit before slab is poured.
      d. Do not install sensor probe until concrete has cured for 48 hours minimum.
      e. After receptacle is installed, pull signal wire from appropriate controller to receptacle box and terminate at terminal block.
   4. Sensor Installation
HMC Architects

a. Install sensor probe into thermowell. Probe tip shall bottom out in thermowell, with at least 1 inch of probe sticking out of thermowell for ease of removal.

b. Do not use thermal grease.

c. Connect leads from sensor probe to terminal block. Verify sensor is visible to controller.

d. This is an exception to the rule requiring home runs and prohibiting splices in signal wires. This is the only acceptable signal wire splice.

e. Test sensor connectivity and accuracy as part of commissioning process and include results with Pre-Functional Test Report.

S. After system balancing has been completed, mark balancing valves to permanently indicate final position.

T. Perform the following adjustments before operating the system:
   1. Open valves to fully open position.
   2. Check operation of automatic valves.
   3. Set temperature controls so all zones call for full flow.
   4. Purge air from piping.

U. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating and/or cooling system as follows:
   1. Start system heating at a maximum of 10 deg F above the ambient radiant-panel temperature and increase 10 deg F each following day until design temperature is achieved.
   2. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.

3.04 FIELD QUALITY CONTROL

A. Prepare radiant heating and/or cooling piping for testing as follows:
   1. Open all isolation valves and close bypass valves.
   2. Open and verify operation of zone control valves.
   3. Flush with clean water and clean strainers.

B. [Engage a factory-authorized service representative to perform][Perform] the following tests and inspections:
   1. Leak Test: After installation and before concrete slab is poured, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 60 psig. Repressurize once after 4 hours if necessary then verify tubing holds pressure for a minimum of 8 hours. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Perform testing as required by Section 23 2113 “Hydronic Piping”.

C. Radiant heating and/or cooling piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.
F. Provide 48 hours advance notice of all inspections to the Owner to witness inspection. Hold for inspection or witness.

END OF SECTION
ADDENDUM NO. 1

5036004 BUILDING AUTOMATION SYSTEMS
D-4014 Diablo Valley College P/K Complex

SECTION 250000
BUILDING AUTOMATION SYSTEMS

PART 1 GENERAL

1.1 Summary

A. Furnish and install a digital Building Automation System (BAS) as specified herein.
B. The like for like equipment replacement of the existing WSHP is to be field verified by the contractor. This is not part of the new construction scope.

1.2 Coordination with other Trades

A. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. This section is provided to assist Contractor in coordination of work scope but shall not be construed to limit Contractor's scope of work encompassed by the contract documents.
B. The following table is intended to assist the Contractors in coordinating the scope of work between Division 25 Building Automation System (indicated as 25), and other Divisions as indicated. However, the General Contractor is ultimately responsible for coordination among his subcontractors regardless of what is listed in this Section.

<table>
<thead>
<tr>
<th>INTERFACE / RESPONSIBILITY MATRIX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>System</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Division under which the following is specified</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A. FIRE &amp; LIFE SAFETY SYSTEMS</td>
</tr>
<tr>
<td>1. Fire alarm controls</td>
</tr>
<tr>
<td>2. Duct mounted &amp; in-duct mounted smoke detectors</td>
</tr>
<tr>
<td>3. Other smoke detectors</td>
</tr>
<tr>
<td>4. Smoke control interlocks to HVAC fans</td>
</tr>
<tr>
<td>5. Smoke dampers with electric actuators</td>
</tr>
<tr>
<td>6. Smoke damper end switches</td>
</tr>
<tr>
<td>B. MECHANICAL EQUIPMENT</td>
</tr>
<tr>
<td>1. Unitary mechanical equipment</td>
</tr>
<tr>
<td>2. ASHP</td>
</tr>
</tbody>
</table>
## INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### C. BUILDING AUTOMATION SYSTEM (BAS)

1. Central control workstations & servers | - | - | - | - | Existing
2. Control system network backbone | 25 | 25 | 25 | 25 |
3. Line voltage control devices to 120V motors | 25 | 26 | 26 | 26 |
4. Window switches | 25 | 25 | - | 25 |
5. Control panels | 25 | 25 | 26/2 | 25 |

### D. ELECTRICAL SYSTEMS

1. Lighting Control BACnet gateway | 26 | 26 | 26 | 25 |
2. Lighting relay panels and low voltage switches | 26 | 26 | 26 | 26 |
3. Lighting occupancy sensors | 26 | 26 | 26 | 26 |
4. Daylighting sensors and controls | 26 | 26 | 26 | 26 |
5. Power monitoring sensors and gateway | 26 | 26 | 26 | 26/25 |

### E. PLUMBING SYSTEMS

1. Gas and water flow meters | 25 | 22 | 25 | 25 |
2. Recirculation pumps or heat tape | 22 | 22 | 26 | 25 |
3. Pipe gauges, thermometers, test plugs | 22 | 22 | - | - |
## INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Control &amp; interlock wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Self-powered valves, pressure relief valves, liquid level controllers, etc.</td>
<td>22</td>
<td>22</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5. Sensor wells, meters and other pipe-mounted control devices</td>
<td>25</td>
<td>22</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

### F. HVAC HYDRONIC SYSTEMS

1. Pipe gauges, thermometers, test plugs
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

2. Self-powered valves, refrigerant powered head pressure control valves, pressure relief valves, liquid level controllers, etc.
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

3. Automatic isolation and control valves
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>23</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

4. Sensor wells, meters and other pipe-mounted control devices
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>23</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

### G. HVAC SHEET METAL

1. Duct mounted sensors
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>23</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

2. Control dampers
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

3. Control damper actuators
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

### H. PACKAGED VAV AIR CONDITIONING SYSTEMS

1. AC unit including all controls
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>

2. Gateway to BAS
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>23</td>
<td>25</td>
</tr>
</tbody>
</table>

### I. HVAC TERMINAL BOXES

1. Terminal box control transformer panel
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
<td>26/2 5</td>
<td>25</td>
</tr>
</tbody>
</table>

2. Terminal box with damper
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

3. Digital controller and damper actuator
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

4. Air-flow measurement pickup
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>23</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

5. Air-flow measurement transducer and piping
<table>
<thead>
<tr>
<th>Equipment</th>
<th>Installation</th>
<th>Power wiring</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>System</td>
<td>Division under which the following is specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
<td>Power wiring</td>
</tr>
<tr>
<td>7. Terminal fan</td>
<td>23</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>8. Electric reheat coil, including control transformer, safeties &amp; contactors</td>
<td>23</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>9. HW control valve and actuator</td>
<td>25</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>J. MISCELLANEOUS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ceiling and wall access doors and panels</td>
<td>8</td>
<td>8</td>
<td>-</td>
</tr>
</tbody>
</table>

**NUMBERED REMARKS:**

1. Wiring includes raceway, fittings, wire, boxes and related items, all voltages.
2. Wiring and controls to start and stop fans based on smoke detector status and smoke control logic specified under Division 26 Electrical.
3. Factory installed starters and variable speed drives are specified under Division 23 HVAC. Prewired control panel is specified under Division 23 HVAC; single point power connection (unless otherwise noted on drawings) specified by Division 23 HVAC.
4. Applies to motors that are not covered by note Integral starter control devices such as HOA switches, 120V control transformers specified under Division 26 Electrical.
5. Single phase 120V motors with integral motor overload protection specified under Division 23 HVAC.
6. Line voltage control device such as thermostat or switch specified under Division 25 BAS; wiring and conduit between control device and motor specified under Division 26 Electrical.
7. Factory installed and wired chilled and condenser water flow switches are specified under Division 23 HVAC; no work is required under Division 25 BAS. Bi-directional (read/write) factory installed BACnet gateway between the BAS and ASHP control panel specified with ASHP under Division 23 HVAC; control wiring specified under Division 25 BAS. ASHP vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across ASHP points to the BAS.
8. Disconnects or circuit breakers are specified under Division 23 HVAC where specifically called for in equipment schedules or specifications to be factory installed with equipment. Otherwise all disconnects are specified under Division 26 Electrical.
<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
</tr>
<tr>
<td>9. Emergency override switches, status lights and other refrigerant machinery room controls as required by CMC are specified under Division 25 BAS.</td>
<td></td>
</tr>
<tr>
<td>10. TDS controller, bleed valve, injector pump, make-up water flow meter, and all other water treatment system controls are specified under Division 23 HVAC. Field wiring of all components is specified under Division 25 BAS.</td>
<td></td>
</tr>
<tr>
<td>11. Network wiring and routers within building is specified under Division 25 BAS. Connection to campus IT LAN shall be wired by others to main building control panel. Division 25 BAS shall coordinate with campus IT for IP address.</td>
<td></td>
</tr>
<tr>
<td>12. Lighting control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across lighting control points to the BAS.</td>
<td></td>
</tr>
<tr>
<td>13. Power measuring sensors, installation and wiring to a single central controller with Modbus interface specified under Division 26 Electrical. Modbus gateway and network connection from gateway to BAS specified under Division 25 BAS. Power monitoring control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across power monitoring control points to the BAS.</td>
<td></td>
</tr>
<tr>
<td>14. Hoods, including all required fire protection devices and integral listed balancing dampers, are specified under Division 11 Food Service.</td>
<td></td>
</tr>
<tr>
<td>15. Ansul type fire protection system is specified under Division 11 Food Service including all control wiring between Ansul hood and fire suppression panel, power wiring to fire suppression panel, fire alarm system monitoring intertie, gas shut-off valve interlock, and circuit breaker shunt-trips for all equipment located under the hoods.</td>
<td></td>
</tr>
<tr>
<td>16. PCUs with factory pre-piped fire suppression nozzles and fusible link detector brackets for Ansul type fire protection system is specified under Division 23. Field connection, tanks, controls, fusible link detectors, and commissioning is specified under Division 11 Food Service as part of hood fire protection system.</td>
<td></td>
</tr>
<tr>
<td>17. Duct access doors required for access to control devices where required specified under Division 23 HVAC.</td>
<td></td>
</tr>
<tr>
<td>18. Actuators for motorized dampers supplied with fans or hoods where scheduled on HVAC drawings are specified under Division 23 HVAC, mounted but not wired.</td>
<td></td>
</tr>
<tr>
<td>19. BACnet gateway to BAS specified in the Division 23 HVAC, factory installed, with connection of gateway to BAS specified under Division 25 BAS. AC vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping AC control points to the BAS.</td>
<td></td>
</tr>
</tbody>
</table>
### INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
</tr>
</tbody>
</table>


21. Control transformers for terminal boxes shall be centralized in control panels specified under Division 25 BAS.

22. Factory wired control transformer, safeties and contactors with single point power wiring connection specified under Division 23 HVAC.

---

### 1.3 Integration with Existing System

A. Include all services required to integrate this building into existing BAS for a fully operational system.

B. Procedure

1. Provide all controls work within the building as indicated on Drawings and in this Section.

2. Develop all building level control system databases and control programming using existing standards and standard programming.

3. Install building databases and control programming on a temporary portable operator’s terminal provided by the Contractor. The POT shall be used for start-up, testing, and commissioning. The POT shall remain the property of the Contractor after final completion of the project.

4. Once the building BAS has been fully commissioned and accepted by the College, merge database and programming with those existing on the Control System Servers. Confirm that the merge was successful by sample testing points and sequences and approve final installation in writing.

5. Integrate graphic screens into the Central Plant graphics including adding appropriate hyperlinks so that the system operates as one integrated system.

6. Provide high level password for College operator access to the system only at this point; College will not have access to the system prior to system acceptance and integration.

### 1.4 Reference Standards

A. Nothing in Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, and regulations. When Contract Documents differ
from requirements of applicable laws, ordinances, rules and regulations, comply with
documents establishing the more stringent requirement.

B. The latest published or effective editions, including approved addenda or
amendments, of the following codes and standard shall apply to the BAS design and
installation as applicable.

C. State, Local, and City Codes
   1. CBC – California Building Code
   2. CMC – California Mechanical Code
   3. CEC – California Electrical Code
   4. Local City and County Codes

D. American Society of Heating, Refrigeration and Air Conditioning Engineers
   (ASHRAE)
   1. ANSI/ASHRAE 135 – BACnet - A Data Communication Protocol for Building
      Automation and Control Networks.

E. Electronics Industries Alliance
   1. EIA-232 – Interface Between Data Terminal Equipment and Data Circuit-
      Terminating Equipment Employing Serial Binary Data Interchange.
   3. EIA-485 – Standard for Electrical Characteristics of Generator and Receivers for
      use in Balanced Digital Multipoint Systems.
   4. EIA-472 – General and Sectional Specifications for Fiber Optic Cable.
   5. EIA-475 – Generic and Sectional Specifications for Fiber Optic Connectors and
      all Sectional Specifications.
   6. EIA-573 – Generic and Sectional Specifications for Field Portable Polishing
      Device for Preparation Optical Fiber and all Sectional Specifications.
   7. EIA-590 – Standard for Physical Location and Protection of Below-Ground Fiber
      Optic Cable Plant and all Sectional Specifications.

F. Underwriters Laboratories

G. National Electrical Manufacturers Association
   1. NEMA 250 – Enclosure for Electrical Equipment.

H. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 142 – Recommended Practice for Grounding of Industrial and Commercial
      Power Systems.
   2. IEEE 802.3 – CSMA/CD (Ethernet – Based) LAN.
   3. IEEE 802.4 – Token Bus Working Group (ARCNET – Based) LAN.
1.5 Definitions

A. Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAC</td>
<td>Advanced Application Controller</td>
</tr>
<tr>
<td>AH</td>
<td>Air Handler</td>
</tr>
<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
</tr>
<tr>
<td>AI</td>
<td>Analog Input</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>ASC</td>
<td>Application Specific Controllers</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration and Air Conditioning Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>A-to-D</td>
<td>Analog-to-Digital</td>
</tr>
<tr>
<td>BACnet</td>
<td>Data Communications Protocol for Building Automation and Control Systems</td>
</tr>
<tr>
<td>BC</td>
<td>Building Controller</td>
</tr>
<tr>
<td>BIBB</td>
<td>BACnet Interoperability Building Blocks</td>
</tr>
<tr>
<td>BTL</td>
<td>BACnet Testing Laboratory</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Drafting</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>CHWR</td>
<td>Chilled Water Return</td>
</tr>
<tr>
<td>CHWS</td>
<td>Chilled Water Supply</td>
</tr>
<tr>
<td>COV</td>
<td>Change of Value</td>
</tr>
<tr>
<td>CSS</td>
<td>Control Systems Server</td>
</tr>
<tr>
<td>CU</td>
<td>Controller or Control Unit</td>
</tr>
<tr>
<td>CV</td>
<td>Constant Volume</td>
</tr>
<tr>
<td>CW</td>
<td>Condenser Water</td>
</tr>
<tr>
<td>CWR</td>
<td>Condenser Water Return</td>
</tr>
<tr>
<td>CWS</td>
<td>Condenser Water Supply</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>DHW</td>
<td>Domestic Hot Water</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>D-to-A</td>
<td>Digital-to-Analog</td>
</tr>
<tr>
<td>BAS</td>
<td>Building Automation System</td>
</tr>
<tr>
<td>EMT</td>
<td>Electrical Metallic Tubing</td>
</tr>
<tr>
<td>EP</td>
<td>Electro-Pneumatic</td>
</tr>
<tr>
<td>ETL</td>
<td>Edison Testing Laboratories</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand Held Device</td>
</tr>
<tr>
<td>HOA</td>
<td>Hand-Off-Automatic</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilating and Air-Conditioning</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper-Text Transfer Protocol</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/output</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LANID</td>
<td>LAN Interface Device</td>
</tr>
<tr>
<td>MAC</td>
<td>Medium Access Control</td>
</tr>
<tr>
<td>MHz</td>
<td>Megahertz</td>
</tr>
<tr>
<td>MS/TP</td>
<td>Master-Slave/Token-Passing</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>ODBC</td>
<td>Open Database Connectivity</td>
</tr>
<tr>
<td>OI</td>
<td>Operator Interface</td>
</tr>
<tr>
<td>OWS</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>P</td>
<td>Proportional</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PI</td>
<td>Proportional-Integral</td>
</tr>
<tr>
<td>PICS</td>
<td>Protocol Implementation Conformance Statement</td>
</tr>
</tbody>
</table>
### Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible</td>
<td>Locations that can be reached with no more than a ladder to assist access and</td>
</tr>
<tr>
<td></td>
<td>without having to remove permanent partitions or materials. Examples include</td>
</tr>
<tr>
<td></td>
<td>inside mechanical rooms, mechanical equipment enclosures, instrument panels,</td>
</tr>
<tr>
<td></td>
<td>and above suspended ceilings with removable tiles.</td>
</tr>
<tr>
<td>BACnet Interoperability</td>
<td>A BIBB defines a small portion of BACnet functionality that is needed to</td>
</tr>
<tr>
<td>Building Blocks</td>
<td>perform a particular task. BIBBs are combined to build the BACnet</td>
</tr>
<tr>
<td></td>
<td>functional requirements for a device in a specification.</td>
</tr>
<tr>
<td>BACnet/BACnet Standard</td>
<td>BACnet communication requirements as defined by the latest version of ASHRAE/</td>
</tr>
<tr>
<td></td>
<td>ANSI 135 and approved addenda.</td>
</tr>
<tr>
<td>Change of Value</td>
<td>An event that occurs when a digital point changes value or an analog value</td>
</tr>
<tr>
<td></td>
<td>changes by a predefined amount.</td>
</tr>
<tr>
<td>Client</td>
<td>A device that is the requestor of services from a server. A client device</td>
</tr>
<tr>
<td></td>
<td>makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Concealed</td>
<td>Embedded in masonry or other construction, installed in furred spaces,</td>
</tr>
<tr>
<td></td>
<td>within double partitions, above hung ceilings, in trenches, in crawl spaces,</td>
</tr>
<tr>
<td></td>
<td>or in enclosures.</td>
</tr>
</tbody>
</table>

---

**PID** : Proportional-Integral-Derivative  
**POT** : Portable Operators Terminal  
**PTP** : Point-to-Point  
**RAM** : Random Access Memory  
**SOO** : Sequence of Operation  
**SQL** : Standardized Query Language  
**SSL** : Secure Socket Layers  
**TAB** : Test, Adjust, and Balance  
**TDR** : Time Delay Relay  
**UFT** : Underfloor Fan Terminal Box  
**UL** : Underwriters’ Laboratories, Inc.  
**XML** : Extensible Markup Language
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Monitoring</td>
<td>A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).</td>
</tr>
<tr>
<td>Contract Documents</td>
<td>Specifications, drawings, and other materials provided with request for bids.</td>
</tr>
<tr>
<td>Control Systems Server</td>
<td>A computer(s) that maintain(s) the systems configuration and programming database.</td>
</tr>
<tr>
<td>Controller</td>
<td>Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.</td>
</tr>
<tr>
<td>Direct Digital Control</td>
<td>Microprocessor-based control including Analog/Digital conversion and program logic.</td>
</tr>
<tr>
<td>Building Automation System</td>
<td>The entire integrated management and control system.</td>
</tr>
<tr>
<td>Equal</td>
<td>Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.</td>
</tr>
<tr>
<td>Exposed</td>
<td>Not installed underground or concealed.</td>
</tr>
<tr>
<td>Furnish</td>
<td>To purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Gateway</td>
<td>Bi-directional protocol translator connecting control systems that use different communication protocols.</td>
</tr>
<tr>
<td>Hand Held Device</td>
<td>Manufacturer’s microprocessor based portable device for direct connection to a field Controller.</td>
</tr>
<tr>
<td>Inaccessible</td>
<td>Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.</td>
</tr>
<tr>
<td>Indicated, shown or noted</td>
<td>As indicated, shown or noted on drawings or specifications.</td>
</tr>
<tr>
<td>Install</td>
<td>To erect, mount and connect complete with related accessories.</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the BAS.</td>
</tr>
<tr>
<td>IT LAN</td>
<td>Reference to the facility’s Information Technology network, used for normal business-related e-mail and Internet communication.</td>
</tr>
<tr>
<td>LAN Interface Device</td>
<td>Device or function used to facilitate communication and sharing of data throughout the BAS.</td>
</tr>
<tr>
<td>Local Area Network</td>
<td>Computer or control system communications network limited to local building or campus.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Master-Slave/Token Passing</td>
<td>Data link protocol as defined by the BACnet standard.</td>
</tr>
<tr>
<td>Motor Controllers</td>
<td>Starters, variable speed drives, and other devices controlling the operation of motors.</td>
</tr>
<tr>
<td>Native BACnet Device</td>
<td>A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.</td>
</tr>
<tr>
<td>Native BACnet System</td>
<td>A network composed only of Native BACnet Devices without gateways.</td>
</tr>
<tr>
<td>Open Database Connectivity</td>
<td>An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Open Connectivity</td>
<td>OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Operator Interface</td>
<td>A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.</td>
</tr>
<tr>
<td>Operator Workstation</td>
<td>The user’s interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.</td>
</tr>
<tr>
<td>Owner</td>
<td>The Owner or their designated representatives.</td>
</tr>
<tr>
<td>Piping</td>
<td>Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.</td>
</tr>
<tr>
<td>Points</td>
<td>All physical I/O points, virtual points, and all application program parameters.</td>
</tr>
<tr>
<td>Point-to-Point</td>
<td>Serial communication as defined in the BACnet standard.</td>
</tr>
<tr>
<td>Portable Operators Terminal</td>
<td>Laptop PC used both for direct connection to a controller and for remote dial up connection.</td>
</tr>
<tr>
<td>Primary Controlling LAN</td>
<td>High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs.</td>
</tr>
<tr>
<td>Protocol Implementation Conformance Statement</td>
<td>A written document that identifies the particular options specified by BACnet that are implemented in a device.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Provide</td>
<td>Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.</td>
</tr>
<tr>
<td>Reviewed, approved, or directed</td>
<td>Reviewed, approved, or directed by or to Owner’s Representative.</td>
</tr>
<tr>
<td>Router</td>
<td>A device that connects two or more networks at the network layer.</td>
</tr>
<tr>
<td>Secondary Controlling LAN</td>
<td>LAN connecting AACs and ASCs.</td>
</tr>
<tr>
<td>Server</td>
<td>A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Standardized Query Language</td>
<td>SQL - A standardized means for requesting information from a database.</td>
</tr>
<tr>
<td>Supervisory LAN</td>
<td>Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.</td>
</tr>
<tr>
<td>Supply</td>
<td>Purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Wiring</td>
<td>Raceway, fittings, wire, boxes and related items.</td>
</tr>
<tr>
<td>Work</td>
<td>Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.</td>
</tr>
</tbody>
</table>

1.6 Quality Assurance
A. Materials and Equipment
B. Installer
   1. The following are approved BAS contractors:
      a. Sunbelt. Marc Annicchero mannichero@sunbeltcontrols.com
      b. Air Systems. Mike Putich Mike.Putich@airsystemsinc.com
      c. ASG: Tony Skibinski tskibinski@asgbms.com
   2. BAS Contractor’s Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 projects of similar size and complexity. Project Manager must have proof of having successfully completed the most advanced training offered by the manufacturer of the proposed product line.
3. BAS Contractor’s Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.

4. BAS Contractor’s Lead Installation Technician Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system installation for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Installers must show proof of having successfully completed the installation certification training offered by the vendor of the proposed product line.

5. BAS Contractor’s Service Qualifications: The installer must be experienced in control system operation, maintenance and service. BAS Contractor must document a minimum 5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.

6. Installer’s Response Time and Proximity
   a. Installer must maintain a fully capable service facility within 50 miles of the subject Project. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
   b. Installer must demonstrate the ability to meet the emergency response times listed

7. Electrical installation shall be by manufacturer-trained electricians
   a. Exception: Roughing in wiring and conduit and mounting panels may be subcontracted to any licensed electrician.

1.7 Submittals
   A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner’s Representative.
   B. Submit drawings and product data as hereinafter specified. Conditions in this Section take precedence over conditions in Division 1 or Section 230501 Basic Mechanical Materials and Methods.
   C. Submittal Schedule: Submittal schedule shall be as follows unless otherwise directed by the Owner’s Representative:
      1. Allow 10 working days for approval, unless Owner’s Representative agrees to accelerated schedule.
      2. Submittal Package 0 (Qualifications) shall be submitted with bid.
      3. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by the Owner in bid documents.
      4. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.
5. Submittal Package 3 (Functional Testing) shall be submitted no less than 30 days prior to conducting tests.

6. Submittal Package 4 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.

7. Submittal Package 5 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation. The list of points to be trended shall be submitted for approval 14 days prior to the start of the trend collection period.

D. Submission and Resubmission Procedure

1. Optional Pre-Submittals. At Contractor’s option, electronic submittals indicated below may be submitted unofficially via email directly to the Engineer for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time.

2. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as SUBMITTAL 250000-01.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 250000-01 REVISION 1.

4. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.

5. Owner’s Representative will return a memo or mark-up of submittal with comments and corrections noted where required.

6. Make corrections
   a. Revise initial submittal to resolve review comments and corrections.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.

7. Resubmit revised submittals until no exceptions are taken.

8. Once submittals are accepted with no exceptions taken, provide
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Photocopies or electronic copies for coordination with other trades, if and as required by the General Contractor or Owner’s Representative.

E. Submittals Packages

1. Submittal Package 0 (Qualifications)
   a. Provide Installer and Key personnel qualifications as
   b. Format: Word-searchable format

2. Submittal Package 1 (Hardware and Shop Drawings)
a. Hardware

1) Organize by specification section and device tags as tagged in these specifications.

2) Do not submit products that are not used even if included in specifications.

3) Include a summary table of contents listing for every submitted device:
   a) Tab of submittal file/binder where submittal is located
   b) Device tag as tagged in these specifications (such as TS-1A, FM-1)
   c) Specification section number (down to the lowest applicable heading number)
   d) Whether device is per specifications and a listed product or a substitution
   e) Manufacturer
   f) Model number
   g) Device accuracy (where applicable)
   h) Accuracy as installed including wiring and A/D conversion effects (where applicable)

4) Submittal shall include manufacturer's description and technical data, such as performance data and accuracy, product specification sheets, and installation instructions for all control devices and software.

5) When manufacturer’s cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the Project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.

6) Format: Word-searchable format per Paragraph

b. Shop Drawings

1) System architecture one-line diagram indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate address and type for each control unit. Indicate media, protocol, baud rate, and type of each LAN.

2) Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. The schematics provided on Drawings shall be the basis of the schematics with respect to layout and location of control points.

3) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.

4) Label each input and output with the appropriate range.
5) Device table (Bill of Materials). With each schematic, provide a table of all materials and equipment including:
   a) Device tag as indicated in the schematic and actual field labeling (use tag as indicated in these specifications where applicable and practical)
   b) Device tag as indicated in these specifications where applicable and if it differs from schematic device tag
   c) Description
   d) Proposed manufacturer and model number
   e) Range
   f) Quantity

6) With each schematic or on separate valve sheet, provide valve and actuator information including pipe size, valve size, \( C_v \), design flow, target pressure drop, actual design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of fail-safe valves and dampers.

7) Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

8) Details of control panels, including controllers, instruments, and labeling shown in plan or elevation indicating the installed locations.

9) Floor plans: None required.

10) Format
   a) Sheets shall be consecutively numbered.
   b) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
   c) Table of Contents listing sheet titles and sheet numbers.
   d) Legend and list of abbreviations.
   e) Schematics
      1. Word searchable pdf format.
      2. 21-inch x 15 inch or 17 inch x 11 inch.
   c. Do not include sequence of controls on shop drawings or equipment submittals; they are included in Submittal Package 2.
   3. Submittal Package 2 (Programming and Graphics)
a. A detailed description of point naming convention conforming to district standard to be used for all software and hardware points, integrated with existing database convention.

b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.

c. Control Logic Documentation

1) Submit control logic program listings (graphical programming) consistent with specified English-language Sequences of Operation for all control units.

2) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.

3) Include specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. SOO shall be fully consistent with the graphical programming. (An electronic version of the sequences of controls in Paragraph 3.13 will be provided to the Contractor upon request.)

4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.

5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.

d. Graphic screens of all required graphics provided in final colors.

e. Format

1) Points list: Word-searchable format per Paragraph

2) Programming: Native ALC Eikon.

3) Programming and operating manual: Word-searchable format per Paragraph

4) Graphics: Graphical electronic format (pdf, png, etc.).

4. Submittal Package 3 (Functional Testing)

a. Provide pre-functional test forms as required

b. Provide functional test forms as

c. Format: Word-searchable format

5. Submittal Package 4 (Training Materials)

a. Provide training materials as required by Paragraph 3.11.

b. Format: Word-searchable format

6. Submittal Package 5 (Trend Logs)
a. Provide a list of points being trended along with trend interval or change-of-value
b. Provide trend logs as required.

1.8 Completion Requirements

A. Procedure

1. Until the documents required in this Section are submitted and approved, the system will not be considered accepted and final payment to Contractor will not be made.

2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of Owner.

3. After review, furnish quantity of sets indicated below to Owner.

B. Completion Documents

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format

a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.

b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.

c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.

e. A list of recommended spare parts with part numbers and suppliers.

f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.

g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.

h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

i. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.
j. English language control sequences updated to reflect final programming installed in the BAS at the time of system acceptance.

k. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.

2. Complete original issue electronic copy for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

3. Complete electronic copy of BAS database, user screens, setpoints and all configuration settings necessary to allow re-installation of system after crash or replacement of server, and resume operations with the BAS in the same configuration as during owner sign-off.

4. Project Record Drawings
   a. As-built versions of the submittal drawings in reproducible paper and electronic format.
   b. As-built network architecture drawings showing all BACnet nodes including a description field with specific controller and device identification, description and location information.

5. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc

6. Copy of inspection certificates provided by the local code authorities.

7. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.

8. Training materials as required

9. Contact information. Names, addresses, and 24-hour telephone numbers of contractors installing equipment, and the control systems and service representatives of each.

C. Format of Completion Documents

1. Provide the type and quantity of media listed in table below.

2. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).

3. Where electronic copies are specified, comply with the following:
   a. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf), and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.
   b. For submittals, provide separate file for each type of equipment.
   c. Control sequences shall be in MS Word.
### D. Permanent On-site Documentation

1. In panels, provide the following in a sufficiently permanent manner such that documentation cannot be easily removed (and lost):
   a. Point list of all points in panel.
   b. Shop drawings for devices in panel.

### 1.9 BAS Design

#### A. System Architecture

1. General
   a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified in this Section. Include all items not specifically itemized in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Section.
   b. The system shall be configured as a distributed processing network(s) capable of expansion as specified herein.
   c. The existing Campus BAS consists of a control system server interconnected by a high-speed Supervisory LAN to each campus building and facility. This project includes integrating building level BCs and other control devices into the campus system.
      1) Within the building, the BAS shall be standalone and not rely on any 3rd party networks, such as the Campus IT LAN.
2) To communicate with the central CSS (and internet via VPN), the building Supervisory LAN shall connect via router, provided under Division 25, to the Campus IT LAN, provided by the College IT group. Locate in building MDF or other location as directed by the College IT group.

d. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ANSI/ASHRAE Standard 135.

2. BAS Network Architecture

a. Supervisory LAN: The LAN shall be an Ethernet-based, 100 or 1000 Mbps network connecting the server and OWS(s) and to certain gateways as specified herein. Provide this as a dedicated LAN for the control system; the Campus IT LAN shall not be used for this purpose. LAN shall be IEEE 802.3 Ethernet with switches and routers that support 100 Mbps minimum throughput. Power-line carrier communication are not acceptable for communications. This network shall be BACnet/IP as defined in the BACnet standard and shall share a common network number for the Ethernet backbone, as defined in BACnet.

i) Supervisory LAN shall be extended to the following mechanical rooms (to allow POTs to connect to system using browser and to improve throughput of trend data)

   a) ASHP
   b) Penthouse AHU, EF

b. Primary Controller LAN (Primary LAN): High-speed, peer-to-peer communicating LAN used to connect BCs, AACs, and certain gateways where specified herein. The Primary LAN communicates exclusively control information. Acceptable technologies include and are limited to:

   1) Ethernet (IEEE802.3)
   2) ARCNET (IEEE802.4)

c. Secondary Controller LAN (Secondary LAN): Network used to connect ASCs and certain gateways where specified herein. These may be Master Slave/Token Passing (MS/TP) in addition to those allowed for Primary Controller LANs. Network speed versus the number of controllers on the LAN shall be dictated by the response time and trending requirements.

3. Operator Interfaces and Servers. The Control Systems Server (CSS) and Operator interface devices are existing. No additional CSS, OWS, or POT shall be provided as a part of this project for temporary CSS requirements.

4. Controllers. The BCs, AACs, and ASCs shall monitor, control, and provide the field interface for all points specified.

5. Gateways

a. Where gateways are used, critical points shall be hardwired from the BAS to the controlled device, rather than using the gateway, to avoid problems with gateway failures, currently a common problem. Critical points are those that are essential for proper operation and are listed in points list as separate
points. Where listed, these points shall be hardwired even when available through gateway.

B. System Performance

1. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. This includes when system is collecting trend data for commissioning and for long term monitoring. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Reconfigure LAN as necessary to accomplish these performance requirements. This does not apply to gateways and their interaction with non-BAS-vendor equipment.

   a. Object Command: The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.

   b. Object Scan: All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.

   c. Graphics Scan: The maximum time between an operator’s selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.

   d. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast (where so programmed) shall not exceed 10 seconds for a Level 1 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.

   e. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

   f. Control Loop Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

2. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

<table>
<thead>
<tr>
<th>Measured Variable</th>
<th>Reported Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space drybulb temperature</td>
<td>±1ºF</td>
</tr>
<tr>
<td>Ducted Air drybulb temperature</td>
<td>±0.5ºF</td>
</tr>
<tr>
<td>Mixed Air drybulb temperature</td>
<td>±1ºF</td>
</tr>
<tr>
<td>Measured Variable</td>
<td>Reported Accuracy</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Outside Air drybulb temperature</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature at central plant mains only</td>
<td>±0.2°F</td>
</tr>
<tr>
<td>Chilled and Condenser Water Temperature – general</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Chilled Water Delta-T (supply to return) at central plant main supply or return only</td>
<td>±0.15°F</td>
</tr>
<tr>
<td>Relative Humidity – general</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Relative Humidity – outdoor air</td>
<td>±3% RH</td>
</tr>
<tr>
<td>Water and Gas Flow</td>
<td>±1% of reading</td>
</tr>
<tr>
<td>Airflow (terminal)</td>
<td>±10% of reading</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±0.05 inches</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±0.01 inches</td>
</tr>
<tr>
<td>Water Pressure</td>
<td>±2% of reading</td>
</tr>
<tr>
<td>Electrical power</td>
<td>1% of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>±75 ppm</td>
</tr>
</tbody>
</table>

1.10 Ownership of Proprietary Material

A. All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:
   1. Project graphic images
   2. Record drawings
   3. Project database
   4. Project-specific application programming code
   5. All documentation

1.11 Warranty

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.
B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for the following periods from date of acceptance:

1. BCs, AACs, and ASCs: two years
2. Valve and damper actuators: five years
3. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Contractor shall respond to the Owner’s request for warranty service within 24 hours during normal business hours.

E. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the Owner during this period.

1.12 Warranty Maintenance

A. The Contractor shall warrant parts and installation work due to malfunction or incorrect initial installation, unless the owner provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

B. At no cost to the Owner, provide maintenance services for software and hardware components during the warranty period as specified below:

1. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming shall be corrected and repaired following notification by the Owner to the Contractor.
   a. Response by telephone to any request for service shall be provided within eight working hours (contractor specified 40 hr. per week normal working period) of the Owner’s initial request for service.
   b. In the event that the malfunction, failure, or defect is covered under warranty, at least one technician, trained in the system to be serviced, shall be dispatched to the Owner’s site within three working days of the Owner’s initial request for such services, as specified.
   c. Seasonal tuning of setpoint variables is not considered part of warranty as the sequence of operations does not change.

2. Owner’s Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One of the three paged/texted technicians shall respond to every call within 15 minutes.

3. Documentation: Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.
PART 2 PRODUCTS

2.1 Primary BAS Manufacturer
   A. Automated Logic Corp.
   B. District Standard, no substitutions

2.2 General
   A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way.
   B. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.
   C. All controllers, associated hardware (repeaters, routers, etc.), sensors, and control devices shall be fully operational and maintain specified accuracy at the anticipated ambient conditions of the installed location as follows:
      1. Outdoors or in harsh ambient conditions: -20°C to 55°C (-4°F to 130°F), 10% RH to 90% RH noncondensing.
      2. Conditioned spaces or mechanical rooms: 0°C to 40°C (32°F to 104°F), 10% RH to 80% RH noncondensing.

2.3 Controllers
   A. Building Controller (BC)
      1. ALC ME-series
   B. Advanced Application Specific Controller (AAC)
      1. ALC SE-series
   C. Application Specific Controller (ASC)
      1. ALC ZN-series

2.4 Communication Devices
   A. Supervisory LAN Routers
      1. ALC LGR and AAR line
   B. BACnet Gateways & Routers
      1. Gateways shall be provided to link non-BACnet control products to the BACnet inter-network. All of the functionality described in this Paragraph is to be provided by using the BACnet capabilities. Each Gateway shall have the ability to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.
      2. Each Gateway shall provide values for all points on the non-BACnet side of the Gateway to BACnet devices as if the values were originating from BACnet objects. The Gateway shall also provide a way for BACnet devices to modify (write) all points specified by the Points List using standard BACnet services.
   C. Gateway and Routers
### Equipment/System

<table>
<thead>
<tr>
<th>Equipment/System</th>
<th>Interface Type</th>
<th>Specified Under Division:</th>
<th>Location</th>
<th>Connect to this Network:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Speed Drives</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each VFD</td>
<td>Secondary</td>
</tr>
<tr>
<td>ASHP</td>
<td>BACnet/IP</td>
<td>23</td>
<td>Each ASHP</td>
<td>Supervisory</td>
</tr>
<tr>
<td>DHW ASHP</td>
<td>BACnet/IP</td>
<td>23</td>
<td>Each ASHP</td>
<td>Supervisory</td>
</tr>
<tr>
<td>Lighting Controls</td>
<td>BACnet/IP</td>
<td>26</td>
<td>Electrical Room</td>
<td>Supervisory</td>
</tr>
<tr>
<td>Power Monitoring</td>
<td>Modbus RS-485</td>
<td>26</td>
<td>Electrical Room</td>
<td>Secondary</td>
</tr>
<tr>
<td>BTU meters</td>
<td>BACnet/MSTP</td>
<td>25</td>
<td>Each BTU meter</td>
<td>Secondary</td>
</tr>
<tr>
<td>Lab Air Valves</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each Air Valve</td>
<td>Secondary</td>
</tr>
<tr>
<td>Water Treatment System</td>
<td>Modbus/IP or BACnet/IP</td>
<td>23</td>
<td>WTS-1</td>
<td>Supervisory</td>
</tr>
</tbody>
</table>

#### 2.5 BAS Interface Hardware

- **A.** Not required (existing)

#### 2.6 Air Tubing

- **A.** Seamless copper tubing, Type L-ACR, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder.

- **B.** Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

#### 2.7 Electric Wiring and Devices

- **A.** All electrical work shall comply with Division 26.

- **B.** Communication Wiring
  
  1. Provide all communication wiring between Building Controllers, Routers, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).

  2. Ethernet LAN: Use Fiber or Category 5 or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.

  3. ARCnet and MS/TP LAN: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30 volts. Shield shall be terminated, and wiring shall be grounded as recommended by BC manufacturer.
C. Analog Signal Wiring
   1. Input and output signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, current or voltage analog outputs, etc. shall be twisted pair, 100% shielded if recommended or required by controller manufacturer, with PVC cover. Gauge shall be as recommended by controller manufacturer.

2.8 Control Cabinets
   A. All control cabinets shall be fully enclosed with hinged door and quarter-turn slotted latch.
   B. Construction
      1. Indoor: NEMA 1
      2. Outdoor: NEMA 3R
   C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.
   D. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.
   E. Provide with
      1. Framed, plastic-encased point list for all points in cabinet.
      2. Nameplates for all devices on face.

2.9 Sensors and Miscellaneous Field Devices
   A. The listing of several sensors or devices in this section does not imply that any may be used. Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Contractor choose among listed products.
   B. Control Valves
      1. Manufacturers
         a. Belimo
         b. Siemens
         c. Invensys
         d. Delta
         e. Or equal
      2. Butterfly Valves
         a. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class bolt pattern to match specified flanges.
b. Seat: EPDM replaceable, non-collapsible, phenolic backed.

c. Disc: Polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.

d. Bearings: Bronze or stainless steel.

e. Shaft: 416 stainless steel supported at three locations with PTFE bushings for positive shaft alignment.

f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.

3. Two Position Ball Valves

a. Valves shall be specifically designed for two-position duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.

b. Industrial quality with nickel plated forged brass body and female NPT threads.

c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (1 inch and smaller) or 400 psi rating (larger than 1 inch). The stem packing shall consist of 2 lubricated O-rings designed for on-off service and requiring no maintenance.

d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.

e. No characterization disks

f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.

g. Ball: Chrome plated brass

h. Stem: Chrome plated brass

4. Modulating Characterized Ball Valves

a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.

b. Industrial quality with nickel plated forged brass body and female NPT threads.

c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.

d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.

e. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.

f. Ball: stainless steel

g. Stem: stainless steel
h. Characterizing disk held securely by a keyed ring providing equal percentage characteristic

5. Six-way Characterized Ball Valves
   a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 230 psi rating. The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. Built-in pressure relief
   f. Close off rating: 50 psi
   g. Ball: chrome plated brass
   h. Stem: nickel plated brass
   i. Characterizing disk held securely by a keyed ring providing linear characteristic

6. Minimum valve assembly pressure ratings
   a. Chilled water: 125 psi at 60°F
   b. Hot water: 125 psi at 200°F
   c. Condenser water: 125 psi at 100°F

7. Valve Selection
   a. Valve type
      1) Modulating 2-way or 3-way valves
         a) 6 inch and less: characterized ball type
         b) 8 inch and greater: globe type
      2) Bypass valve at primary-only variable flow pumping system outlet: Same as Modulating 2-way valve.
      3) Two-position isolation: butterfly or non-characterized ball type
   b. Valve Characteristic
      1) 2-way valves: equal percentage or modified equal percentage.
      2) 3-way valves controlling cooling coils and condenser water heat exchangers: linear.
      3) 3-way valves controlling heating coils: equal percentage or modified equal percentage.
      4) 6-way valves: linear
5) Two-position valves: not applicable. For ball valves used for two-position duty, do not include characterizing disk.

c. Valve Sizing

1) Modulating Water: Size valve to achieve the following full-open pressure drop
   a) Minimum pressure drop: equal to half the pressure drop of coil or exchanger.
   b) Maximum pressure drop
      1. Hot water at coils: 2 psi
      2. Chilled water at coils: 5 psi
   c) 3-way valves shall be selected for near minimum pressure drop. 2-way and 6-way valves shall be selected near maximum pressure drop.
   d) Flow coefficient ($C_v$) shall not be less than 1.0 (to avoid clogging) unless protected by strainer. Verify from piping schematics that a strainer is being provided.
   e) Valve size shall match as close as possible the pipe size where $C_v$ is available in that size.

2) Two-position valves: Line size unless otherwise indicated on Drawings.

C. Control Dampers

1. See Division 23

D. Actuators

1. Manufacturers
   a. Belimo
   b. No equal

2. Warranty: Valve and damper actuators shall carry a manufacturer's 5-year warranty.

3. Electric Actuators
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.

e. Actuator shall have microprocessor-based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.

f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.

g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

h. Modulating Actuators. Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.

i. Where indicated on Drawings or Points List, actuators shall include

1) 2 to 10 VDC position feedback signal
2) Limit (end) position switches

j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.

k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

l. Actuators shall be provided with a conduit fitting an a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

m. Where fail-open or fail-closed (fail-safe) position is required, an internal mechanical, spring return mechanism shall be built into the actuator housing. Electrical capacitor type fail-safe are also acceptable. All fail-safe actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.

n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.

o. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.

p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.
q. Actuators shall provide clear visual indication of damper/valve position.

4. Electric Actuators for Large Butterfly Valves
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.
   c. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   d. Output shaft shall be electroless nickel plated to prevent corrosion.
   e. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time divided by installed time at maximum torque.
   f. Actuator shall be suitable for operation in ambient temperature ranging from -22°F to +150°F.
   g. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.
   h. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
   i. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.
   j. The hand wheel will not rotate while the actuator is electrically driven.
   k. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
   l. Provide limit (end) position switches where indicated on schematics.
   m. Actuators shall provide clear visual indication of valve position.

5. Normal and Fail-Safe Position
   a. Except as specified otherwise herein, the normal position (that with zero control signal) and the fail-safe position (that with no power to the actuator) of control devices and actuators shall be as indicated in table below. “Last” means last position. Actuators with a fail-safe position other than “Last” must have spring or electronic fail-safe capability.

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Fail-Safe Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>Return air damper</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
<tr>
<td>Exhaust/relief air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
</tbody>
</table>
### Device Normal Position Fail-Safe Position

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Fail-Safe Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHU heating coil valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>AHU cooling coil valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>Equipment isolation valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Hot water reheat coil valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>Minimum flow bypass valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Fan-coil HW and CHW valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
<tr>
<td>VAV box dampers</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory hood exhaust air valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory supply air valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
<tr>
<td>Laboratory general exhaust valves</td>
<td>CLOSED</td>
<td>LAST</td>
</tr>
</tbody>
</table>

6. Valve Actuator Selection
   a. Modulating actuators for valves shall have minimum rangeability of 50 to 1.
   b. Water
      1) 2-way, 6-way, and two-position valves
         a) Tight closing against 125% of system pump shut-off head.
         b) Modulating duty against 90% of system pump shut-off head.
      2) 3-way shall be tight closing against twice the full open differential pressure for which they are sized.

7. Damper Actuator Selection
   a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
   b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer’s recommendations and the following:
      1) Torque shall be a minimum 5 inch-pound per square foot for opposed blade dampers and 7 inch-pound per square foot for parallel blade dampers.
      2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer’s maximum area rating.

E. General Field Devices
   1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.
2. It shall be the Contractor’s responsibility to assure that all field devices are compatible with controller hardware and software.

3. Field devices specified herein are generally two-wire type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with two-wire type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, provide a transmitter and necessary regulated DC power supply, as required.

4. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device

F. Temperature Sensors (TS)
   1. General
      a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
      b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3ºF (0.16 ºC) (unless noted otherwise herein).
      c. Sensors shall drift no more than 0.3ºF and shall not require calibration over a five-year period.
      d. Manufacturers
         1) Mamac
         2) Kele Associates
         3) Building Automation Products Inc.
         4) Automated Logic Corp.
         5) Or equal
   2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.
      a. TS-1A: Single point (use where not specifically called out to be averaging in points list). Sensor probe shall be 304 stainless steel.
      b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum. Sensor probe shall be bendable aluminum.
   3. Water Temperature Sensors
      a. TS-2A: Well mounted immersion sensor, ¼” stainless steel probe, double encapsulated sensor, with enclosure suitable for location.
      b. TS-2B: Same as TS-2A except provide extra precision (XP) temperature sensors to meet accuracy specified.
c. TS-2C. See BTU-1.
d. All piping immersion sensors shall be in one-piece machined brass or stainless-steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.

4. Room Sensors
a. Thermostat tags refer to the following:

<table>
<thead>
<tr>
<th>Type</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Blank</td>
</tr>
<tr>
<td></td>
<td>LCD</td>
</tr>
<tr>
<td>Temperature only</td>
<td>TS-3A</td>
</tr>
<tr>
<td></td>
<td>TS-3C</td>
</tr>
<tr>
<td>With CO₂</td>
<td>TS-3AC</td>
</tr>
<tr>
<td></td>
<td>TS-3CC</td>
</tr>
</tbody>
</table>

1) Display
   a) Blank: Blank cover (or LCD display with display configured to be shut off and touchpad or keypad disabled)
   b) LCD: LCD display of all sensors, temperature setpoint adjustment buttons, and schedule override button

2) CO₂ Sensor
   a) 400 to 1250 PPM/±30PPM or 3% of reading, whichever is greater.
   b) The sensor shall include automatic background calibration (ABC) logic to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.
   c) Meet Title 24 requirements including calibration interval

3) For room sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration. Alternative means of terminal calibration are acceptable provided they result in no cost to Work performed under Section 230593 Testing, Adjusting, and Balancing.

b. Unless otherwise indicated in points list or drawings, locate sensors as follows:
   1) Lobbies, corridors, break rooms, and public spaces: TS-3A
   2) Equipment rooms and other back-of-house spaces: TS-3A
   3) Open offices: TS-3A
   4) Private offices: TS-3C
   5) Conference rooms, meeting rooms, etc.: TS-3C
6) Classrooms, labs, training rooms, multi-purpose rooms, etc.: TS-3C
7) Others not listed: Confirm with Engineer through RFI.

5. TS-4: Outdoor Air Sensors
   a. Enclose in fan-aspirated radiation shield that combines both active and passive aspiration to minimize the effects of radiation.
      1) Motor-driven fan draws air through the sensor chamber and exhausts it through the top of the shield.
      2) Triple-walled sensor chamber shielded by flow-through plates.
      3) Aspiration rate: minimum is 220 feet per minute.
   b. Sensor electronics mounted in watertight gasketed enclosure to prevent water seepage
   c. Manufacturer
      1) Davis Instruments 7747
      2) Kele A21
      3) Or equal

G. BTU Meter (BTU-1)
   1. Matched RTD or solid state temperature sensors with a differential temperature accuracy of +/-0.15°F.
   2. Flow meter: FM-1
   3. Unit accuracy shall be +/- 1% factory calibrated, traceable to NIST with certification.
   4. NEMA 1 enclosure.
   5. UL listed.
   6. Provide BACnet/MSTP network connection that will allow all point data to be transmitted to BAS network.
   7. I/O.
      a. BACnet Points:
         1) Supply Temperature
         2) Return Temperature
         3) Flow
         4) Energy Rate (Btu/hr.)
      b. Hardwired Points:
         1) Flow

8. Manufacturers
   a. Onicon System 20
   b. Siemens Sitrans
c. Or Equal

H. Pressure Transmitters (PT)

1. PT-1: Water, General Purpose
   a. Fast-response stainless steel sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.5% full scale, includes non-linearity, repeatability, and hysteresis
   d. Long Term Stability 0.5% FS per year
   e. Pressure Limits
      1) Rated pressure: see points list
      2) Proof pressure = 3x rated pressure
      3) Burst pressure = 5x rated pressure
   f. Manufacturers
      1) Setra 209
      2) Kele & Associates P51 Series
      3) Or equal

I. Differential Pressure Transmitters (DPT)

1. DPT-1: Water, General Purpose
   a. Fast-response capacitance sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
      2) Non-Linearity, BFSL ±0.22% FS.
      3) Hysteresis 0.10% FS.
      4) Non-Repeatability 0.05% FS.
   d. Long Term Stability 0.5% FS per year
   e. Only 316 stainless steel in contact with fluid
   f. Pressure Limits
      1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.
      2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.
   g. Include brass 5-valve assembly for single sensor devices.
   h. Manufacturers
1. Setra 209 or 230
2. Modus W30
3. Or equal

2. DPT-2: Not used

3. DPT-3: Air, Duct Pressure:
   a. General: Loop powered two-wire differential capacitance cell-type transmitter.
   b. Output: two wire 4-20 mA output with zero adjustment.
   c. Overall Accuracy: ±1% of range (not of maximum range/scale)
   d. Switch selectable range:
      1) ≥ 0.5 inches water column
      2) ≤ 10 inches water column
      3) Select range as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.
   e. Housing: Polymer housing suitable for surface mounting.
   f. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal, with connecting tubing.
   g. DPT-3A: Include LCD display of reading.
   h. DPT-3B: Same as DPT-3 except with stainless steel pitot-type static pressure sensing tips similar to Dwyer model A-301-SS, or equal.
   i. Manufacturers.
      1) Setra
      2) Modus
      3) Invensys
      4) Dwyer
      5) Or equal

4. DPT-4: Air, Low Differential Pressure
   a. General: Loop powered, two-wire differential capacitance cell type transmitter.
   b. Output: Two-wire 4-20 mA output with zero adjustment.
   c. Overall Accuracy
      1) General: ±1% FS
      2) Underfloor: ±0.5% FS
      3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS
   d. Range
1) Fixed (non-switch selectable)
2) Minimum Range: 0, -0.1, -0.25, -0.5, or -1.0 inches water column
3) Maximum Range: +0.1, 0.25, 0.5, or 1.0 inches water column
4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.

e. Housing: Polymer housing suitable for surface mounting

f. Static Sensing Element
   1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal
   2) Space sensor: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465, Veris AA05 or equal wall plate sensor
   3) Filter or duct pressure sensor: Dwyer A-301 or equal
   4) Plenum pressure sensor: Dwyer A-421 or equal

5. DPT-4A: Include LCD display of reading

h. Manufacturers
   1) Setra 267
   2) Modus
   3) Air Monitor
   4) Paragon
   5) Or equal

5. DPT-5: VAV Velocity Pressure

a. General: Loop powered two-wire differential capacitance cell type transmitter.
b. Output: Two-wire, 4-20 mA output with zero adjustment.
c. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004 inches differential pressure or lower, shall be capable of sensing 0.002 inches differential pressure or lower, and shall have a ±0.001 inches or lower resolution across the entire scale.
d. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
e. Range: 0 to 1.5 in.w.c.
f. Housing: Polymer housing suitable for surface mounting.
g. Manufacturer
   1) Automated Logic
   2) No equal

J. Differential Pressure Switches (DPS)
1. DPS-1: Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

2. DPS-2: Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Automatic reset. Provide manufacturer’s recommended static pressure sensing tips and connecting tubing.

K. Level Sensor (LS-1)

1. Sensor Element:
   a. Capacitive
   b. Stainless steel

2. Performance
   a. Linearity and Hysteresis: ±0.1% FS
   b. Accuracy: ±0.1% of full scale at constant temperature, ±0.25% over 35°F to 70°F range
   c. Automatic barometric pressure compensation

3. Outputs: 4-20 mA or 0 to Vdc

4. Operating Temperature: -40° to +185°F

5. Housing
   a. NEMA 4X weather tight
   b. Corrosion resistant material

6. Electronics shall be fully encapsulated in marine grade epoxy, guaranteed not to leak

7. Rated for 190°F fluid temperature.

8. Manufacturer
   a. Mercoid Series CRF2
   b. Intempco LTX01
   c. Or equal

L. Current Switches (CS-1)

1. Clamp-on or solid-core

2. Range: as required by application

3. Trip Point: Automatic or adjustable
   a. Exception: Fixed setpoint (Veris H-300 or equal) may be used on direct drive constant speed fans that do not have backdraft or motorized shutoff dampers.

4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage

5. Lower Frequency Limit: 6 Hz
6. Trip Indication: LED
7. Approvals: UL, CSA
8. May be combined with relay for start/stop
9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal
10. Manufacturers
   a. Veris Industries H-608/708/808/908
   b. Senva C-2320L
   c. RE Technologies SCS1150A-LED
   d. Or equal

M. Current Transformers (CT)
   a. Range: 1-10 amps minimum, 20-200 amps maximum
   b. Trip Point: Adjustable
   c. Output: 0-5 Vdc or 0-10 Vdc,
   d. Accuracy: ±0.2% from 20 to 100 Hz.
   e. Manufacturers: Kele SC100, Veris 722, or equal

N. Flow Meter (FM)
1. This is the CCCCD standard for accurate metering of water flows with very low maintenance
2. FM-1: Magnetic Flow Tube Flow Meters
   a. General Requirements
      1) Sensor shall be a magnetic flow meter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
      2) Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
      3) Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.
      4) Flow Tube
         a) ANSI class 150 psig steel
         b) ANSI flanges
c) Lined with
   1. Heating hot water: PTFE, PFA, or ETFE liner rated for 210ºF minimum fluid temperature
   2. Chilled, condenser, domestic hot and cold water: Polypropylene, Ebonite PTFE, PFA, or ETFE liner rated for 140ºF minimum fluid temperature

5) Electrode and grounding material
   a) 316L Stainless steel or Hastelloy C
   b) Electrodes shall be fused to ceramic liner and not require O-rings.

6) Electrical Enclosure: NEMA 4

7) Approvals
   a) UL or CSA
   b) NSF Drinking Water approval for domestic water applications

8) Performance
   a) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and ±0.015 fps from 0.04 fps to 3 fps.
   b) Stability: 0.1% of rate over six months.
   c) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
   d) Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.

b. Manufacturers
   1) Onicon F-3000 series
   2) Siemens/Danfoss Magflo 3100
   3) Krohne Optiflux 4000
   4) Sparling Tigermag EP FM656
   5) Or equal

O. Airflow Measuring Stations (AFMS)
   1. General. AFMS provided under this Section shall be licensed to bear the AMCA Certified Rating Seal for Airflow Measuring Stations. Ratings shall be based on tests and procedures performed in accordance with AMCA Publication 611 and comply with requirements of the AMCA Certified Ratings Program.

   2. AFMS-3. Airflow measurement device and control damper provided with air handling units. See Section 237300 Air Handling Units & Coils.

   3. AFMS-3
      a. Differential pressure type with uniframe DP sensor
1) Provide quantity of DP sensors per manufacturer’s recommendations

b. Extended flow (2 transducers, 0.05" and 0.25" range)

c. Station mounted with expanded metal screen

d. Analog outputs for airflow and temperature

e. Manufacturers

1) Air Monitor OAM-II-2111-MMAB

2) No equal

P. Electric Control Components

1. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.

a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:

1) AC coil pull-in voltage range of +10%, -15% or nominal voltage.

2) Coil sealed volt-amperes (VA) not greater than 4 VA.

3) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.

4) Pilot light indication of power-to-coil and coil retainer clips.

b. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.

c. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

2. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square D, Cutler-Hammer, or equal.

3. Control Transformers and Power Supplies

a. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Mount in minimum NEMA-1 enclosure.

b. Transformer shall be proper size for application. Limit connected loads to 80% of rated capacity.

c. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
d. Separate power transformer shall be used for controllers and for actuators and other end devices that use half wave rectification.

e. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.

f. Line voltage units shall be UL Recognized and CSA Approved.

4. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley, Kele, or equal.

5. Mechanical Timer Switch: Switch shall be mechanically spring wound with a N.O. contact or N.C. contacts as required. Timer shall be 0-60 minutes and shall not include a “hold” feature, which allows switch contacts to remain closed. Contacts shall be rated for minimum 120 VAC operation. Switch shall be C560M type, as manufactured by NSI Industries or equal.

6. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley, Kele, or equal.

7. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, Sonalert solid-state electronic signal, as manufactured by Mallory, Kele, or equal.

8. Potentiometer. Wall box mounted single turn with knob numbered 0 to 10 or 0 to 100. Wall plate cover to match electrical.

9. Window switch (WS)
   a. Surface mount magnetic burglar alarm switch.
   b. Screw mount, magnet on window, switch on frame.
   c. Sealed to prevent dirt or dust contact.
   d. Color to match electrical and lighting switch plates in the room. See Division 26 and Electrical Drawings.

2.10 Calibration & testing Instrumentation

A. Provide instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

2.11 Software

A. General

   1. System software shall be the latest version of ALC WebCTRL.
B. Licensing

1. Include licensing and hardware keys for all software packages at all workstations (OWSs and POTs) and servers.

2. Within the limitations of the server, provide licenses for any number of users to have web access to the CSS at any given time.

3. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

4. All operator software, including that for programming and configuration, shall be available on all workstations. Hardware and software keys to provide all rights shall be installed on all workstations.

C. Graphical User Interface Software

1. Graphics

   a. The GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics and active setpoint graphic controls shall be used to enhance usability.

   b. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.

   c. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.

   d. Links

      1) Graphics shall include hyperlinks which when selected (clicked on with mouse button) launch applications, initiate other graphics, etc.

      2) Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic

      3) Information Links

         a) On each MEP system and subsystem graphic, provide links to display in a new window the information listed below.

            1. English-language as-built control sequence associated with the system.

            2. O&M and submittal information for the devices on the graphic. This includes links to electronic O&M and submittal information for mechanical equipment supplied under Section 230501 Basic Mechanical Materials and Methods.

         b) The display shall identify the target of the link by file name/address.

         c) Information shall be displayed in electronic format that is text searchable.

         d) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software.
e. Point Override Feature

1) Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.

2) When the point is selected to be commanded
   a) Dialog box opens to allow user to override the point (Operator Mode) or release the point (Automatic Mode). Operator Mode will override automatic control of the point from normal control programs.
   b) Dialog box shall have buttons (for digital points) or a text box or slide bar (for analog points) to allow user to set the point’s value when in operator mode. These are grayed out when in automatic mode.
   c) When dialog box is closed, mode and value are sent to controller.
   d) Graphic is updated upon next upload scan of the actual point value.

3) A list of points that are currently in an operator mode shall be available through menu selection.

f. Point override status (if a digital point is overridden by the supervised manual override or if a point is in operator mode) shall be clearly displayed on graphics for each point, such as by changing color or flag.

g. The color of symbols representing equipment shall be able to change color or become animated based on status of binary point to graphically represent on/off status.

2. Alarms

a. ALC WebCTRL Enterprise Integration advanced alarm package configured as indicated below.

3. Trends

a. ALC WebCTRL Enterprise Integration trend package configured as indicated below.

b. Trend Data Storage

1) The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS using SQL queries.

2) Data shall be stored in an SQL compliant database format and shall be available through the Owner’s intranet or internet (with appropriate security clearance) without having to disable BAS access to the database.

3) The database shall not be inherently limited in size, e.g. due to software limitations or lack of a correct license. Database size shall be limited only by the size of the provided storage media (hard drive size).
4. Security Access
   a. Standard ALC WebCTRL security package

5. Report Software
   a. ALC WebCTRL Enterprise Integration advanced reporting package.
   b. Standard reports. Prepare the following standard reports, accessible automatically without requiring definition by user.
      1) Tenant or department after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC services.
      3) Alarm events and status.
      4) Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.

D. Control Programming Software

E. Miscellaneous Software
   1. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide relevant data for the application or object that help is being called from.
   2. Provide software for viewing (but not editing) electronic versions of as-built shop drawings of
      a. Mechanical, electrical, and plumbing systems in Adobe pdf format
      b. BAS drawings in Adobe pdf format

2.12 Control Points
A. Note: CCC district standard points lists are generic in nature and may not be a direct reflection of those available through integration. It is acceptable to provide points that provide points that deliver the same intended functionality. Contractor to RFI for discrepancies where there is no available substitute. Where discrepancies exist between control diagrams, equipment points available, or the sequence of operation, RFI to the district for their meaning to be fully understood. For the intent of this document assume sequence to take highest order of precedence.

B. Table Column Definitions
   1. Point description
   2. Type (number in point schedule after each type refers to tag on schematics)
      a. AO: analog output
b. AI: analog input

c. DO: digital or binary output

d. DI: digital or binary input

3. Trend Logging

a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes.

b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.

c. Trend Basis

1) Where range of engineering units is listed, trend on a change of value (COV) basis (in other words record time stamp and value when point value changes by engineering unit listed).

2) Where time interval is listed, trend on a time basis (in other words record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day, so data can be compared in text format.

4. Calibration

a. F = factory calibration only is required (no field calibration)

b. HH = field calibrate with handheld device.

C. Note that points list below are for each system of like kind. Refer to drawings for quantity of each.

D. Points mapped through gateways and network interfaces

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-issioning</th>
<th>Continuous</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fault reset</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Fault (Critical Alarm)</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Minor Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Fault Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Alarm Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Keypad in hand/auto</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Minimum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
<td>–</td>
</tr>
<tr>
<td>Maximum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
<td>–</td>
</tr>
<tr>
<td>Acceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
<td>–</td>
</tr>
</tbody>
</table>
## ADDENDUM NO. 1

### BUILDING AUTOMATION SYSTEMS

#### 5036004  
D-4014 Diablo Valley College P/K Complex

#### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-issioning</th>
<th>Continuous</th>
<th>Calibra-tion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
<td>–</td>
</tr>
<tr>
<td>Actual frequency</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>AC output voltage</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
<td>F</td>
</tr>
<tr>
<td>Current</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>60 min</td>
<td>F</td>
</tr>
<tr>
<td>VFD temperature</td>
<td>AI</td>
<td>Through network</td>
<td>60 min</td>
<td>60 min</td>
<td>F</td>
</tr>
<tr>
<td>Power, kW</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Energy, MWh</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>60 min</td>
<td>–</td>
</tr>
</tbody>
</table>

#### 2. Air-Cooled Chillers:

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-issioning</th>
<th>Continuous</th>
<th>Calibra-tion</th>
</tr>
</thead>
<tbody>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Alarm</td>
<td>DI or</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Chilled water flow status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Chilled water temperature setpoint reset</td>
<td>AO</td>
<td>Through network</td>
<td>1 min.</td>
<td>±2°F</td>
<td>–</td>
</tr>
<tr>
<td>Chilled water supply temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Chilled water return temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Oil pressure</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
<td>F</td>
</tr>
<tr>
<td>Oil sump temperature</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
<td>F</td>
</tr>
<tr>
<td>Percent of full load current (%FLA)</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
<td>F</td>
</tr>
</tbody>
</table>

#### 3. Heat Pump/Chillers: Not all points available with all manufacturers. Include points listed from each refrigerant circuit.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-issioning</th>
<th>Continuous</th>
<th>Calibra-tion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evap. outlet temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Evap. inlet temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Common Evap. outlet temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
<tr>
<td>Common Evap. inlet temperature</td>
<td>AI</td>
<td>Through network</td>
<td>10 min.</td>
<td>10 min.</td>
<td>F</td>
</tr>
</tbody>
</table>
| Description                          | Type  | Device          | Trend Logging | Calibratio
|-------------------------------------|-------|-----------------|---------------|----------
|                                     |       |                 | Commissioning | Continuous |
| Recovery outlet temperature         | AI    | Through network | 10 min.       | 10 min.   | F        |
| Recovery inlet temperature          | AI    | Through network | 10 min.       | 10 min.   | F        |
| External air temperature            | AI    | Through network | 10 min.       | 10 min.   | F        |
| Refrigerant gas temperature         | AI    | Through network | 10 min.       | 10 min.   | F        |
| Refrigerant liquid temperature      | AI    | Through network | 10 min.       | 10 min.   | F        |
| System dead zone                    | AO    | Through network | 10 min.       | 10 min.   | F        |
| Recovery dead zone                  | AO    | Through network | 10 min.       | 10 min.   |         |
| Defrost current Delta LP            | AI    | Through network | 10 min.       | 10 min.   | F        |
| Auto. Differential HP only          | AO    | Through network | 10 min.       | 10 min.   |         |
| Auto. Differential chiller only      | AO    | Through network | 10 min.       | 10 min.   |         |
| Current system setpoint             | AI    | Through network | 10 min.       | 10 min.   |         |
| Total recovery set-point            | AO    | Through network | 10 min.       | 10 min.   |         |
| Total recovery differential          | AO    | Through network | 10 min.       | 10 min.   |         |
| System summer differential           | AO    | Through network | 10 min.       | 10 min.   |         |
| System winter differential           | AO    | Through network | 10 min.       | 10 min.   |         |
| Setpoint summer                      | AO    | Through network | 10 min.       | 10 min.   |         |
| Setpoint winter                     | AO    | Through network | 10 min.       | 10 min.   |         |
| System On/Off Mode                  | AO    | Through network | 10 min.       | 10 min.   |         |
| Recovery On/Off Mode                | AO    | Through network | 10 min.       | 10 min.   |         |
| Summer winter selection              | AO    | Through network | 10 min.       | 10 min.   |         |
| Mode duration minimum time          | AO    | Through network | 10 min.       | 10 min.   |         |
| System active power                 | AI    | Through network | 10 min.       | 10 min.   | F        |
| Recovery active power               | AI    | Through network | 10 min.       | 10 min.   | F        |
| Unit state                           | AI    | Through network | 10 min.       | 10 min.   |         |
| Total power request                 | AI    | Through network | 10 min.       | 10 min.   |         |
| Fan speed                           | AI    | Through network | 10 min.       | 10 min.   |         |
| Total power request                 | AI    | Through network | 10 min.       | 10 min.   |         |
| defrost State                       | AI    | Through network | 10 min.       | 10 min.   |         |
| Unit On/Off                         | DI    | Through network | COV           | COV       |
| Summer/Winter request               | DO    | Through network | COV           | COV       |
**Addendum No. 1**

**Building Automation Systems**

D-4014 Diablo Valley College P/K Complex

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Comm-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>issiong</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Reset alarms</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>System On/Off</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery On/Off</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Evaporative pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Recovery pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Compressor status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Reversing valve</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Defrost valve</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>All alarms</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

4. Packaged VAV AC units:

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Comm-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>issiong</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Unit on/off</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Cooling enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Economizer enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply air temperature setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±0.5°F</td>
<td>–</td>
</tr>
<tr>
<td>Supply static pressure setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±0.1&quot;</td>
<td>–</td>
</tr>
<tr>
<td>Outdoor airflow cfm</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Minimum OA damper position setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Building static pressure setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>15 min</td>
<td>15 min</td>
</tr>
<tr>
<td>General trouble alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Compressor #x status</td>
<td>DI</td>
<td>Through network, typical of each compressor</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Relief fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Communications alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Return air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Outdoor air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply duct static pressure</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter pressure drop</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Building static pressure</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply fan speed</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Description</td>
<td>Type</td>
<td>Device</td>
<td>Trend Logging</td>
<td>Calibration</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------</td>
<td>--------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Relief fan speed</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Economizer damper position</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Direct evap pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Indirect evap pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Indirect evap fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

5. Electrical System Monitoring. See Division 26 Drawings for quantity of meters and location of network connection.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Real kW</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Volts (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Power factor</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Amps (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

6. BTU Meter (BTU-1)

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Return Temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply Temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Flow</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Btu/h</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

7. Water Treatment System

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Conductivity Setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±10 µOhm</td>
<td>±10 µOhm</td>
</tr>
<tr>
<td>Biocide 1 setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Biocide 2 setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>High conductivity alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Bleed on/off</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Inhibitor feed on/off</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Biocide 1 feed on/off</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>
### 8. Lighting Controls

#### a. Global

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Demand Shed 1</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Demand Shed 2</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Demand Shed 3</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

#### b. For each lighting zone

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Occupancy Sensor State</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

### E. Hardwired Points

1. VAV Box - Cooling only

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAV Box Damper Position</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Local Override</td>
<td>DI</td>
<td>TS-3x – where applicable (see Paragraph Error! Reference source not found.).</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply Airflow</td>
<td>AI</td>
<td>DPT-5 connected to box manufacturer supplied flow cross</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>
### 2. Ventilation Zone VAV Box

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone Temperature Setpoint Adjustment</td>
<td>AI</td>
<td>TS-3x – where applicable (see Paragraph Error! Reference source not found.)</td>
<td>15 min 60 min</td>
<td>F</td>
</tr>
<tr>
<td>Zone Temperature</td>
<td>AI</td>
<td>TS-3x (see Paragraph Error! Reference source not found.)</td>
<td>1 min 15 min</td>
<td>F</td>
</tr>
</tbody>
</table>

### 3. VAV Box with reheat

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone Temperature Setpoint Adjustment</td>
<td>AI</td>
<td>TS-3x – where applicable (see Paragraph Error! Reference source not found.)</td>
<td>15 min 60 min</td>
<td>F</td>
</tr>
<tr>
<td>Zone Temperature</td>
<td>AI</td>
<td>TS-3x (see Paragraph Error! Reference source not found.)</td>
<td>1 min 15 min</td>
<td>F</td>
</tr>
</tbody>
</table>
### ADDENDUM NO. 1

5036004
D-4014 Diablo Valley College P/K Complex

#### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Description</th>
<th>Commisioning</th>
<th>Continuous</th>
<th>Calibra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone Temperature</td>
<td>AI</td>
<td>TS-3x (see Paragraph Error! Reference source not found.)</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Zone CO₂ Concentration</td>
<td>AI</td>
<td>TS-3x (see Paragraph Error! Reference source not found.)</td>
<td>5 min</td>
<td>15 min</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

### 4. VAV Air Handler with Relief Fan

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Description</th>
<th>Commisioning</th>
<th>Continuous</th>
<th>Calibra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relief damper -1 open/close</td>
<td>DO</td>
<td>Two position actuator</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Relief damper -2 open/close</td>
<td>DO</td>
<td>Two position actuator</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Relief Fan 1 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Relief Fan 2 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan 1 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan 2 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply fan high static alarm reset</td>
<td>DO</td>
<td>Dry contact to 120V or 24V control circuit –see control sequences for details</td>
<td></td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Economizer Outdoor Air Damper</td>
<td>AO</td>
<td>Modulating actuator</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Relief Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Return Air Damper</td>
<td>AO</td>
<td>Modulating actuator</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Hot Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Chilled Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Outdoor Airflow</td>
<td>AI</td>
<td>AFMS-3 cfm output</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Outdoor Air Temperature</td>
<td>AI</td>
<td>AFMS-3 temperature output</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>AI</td>
<td>TS-1B across filter bank</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td></td>
<td>–</td>
<td>60 min</td>
<td>F</td>
</tr>
<tr>
<td>Return Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td></td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
</tbody>
</table>
### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-</th>
<th>Continu</th>
<th>Calibra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>issioning</td>
<td>ous</td>
<td>tion</td>
</tr>
<tr>
<td>Supply Air Temperature</td>
<td>AI</td>
<td>TS-1B</td>
<td>1 min</td>
<td>15 min</td>
<td>HH</td>
</tr>
<tr>
<td>Duct Static Pressure</td>
<td>AI</td>
<td>DPT-3A, 0 to 2 inches</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Building Pressure</td>
<td>AI</td>
<td>DPT-4, ±0.25</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
</tbody>
</table>

5. VAV Air Handler with Return Fan

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Comm-</th>
<th>Continu</th>
<th>Calibra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>issioning</td>
<td>ous</td>
<td>tion</td>
</tr>
<tr>
<td>Supply Fan 1 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan 2 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Return Fan 1 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Return Fan 2 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Return fan high static alarm reset</td>
<td>DO</td>
<td>Dry contact to 120V or 24V control circuit – see control sequences for details</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply fan high static alarm reset</td>
<td>DO</td>
<td>Dry contact to 120V or 24V control circuit – see control sequences for details</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Exhaust Air Damper</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Economizer Outdoor Air Damper</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Return Air Damper</td>
<td>AO</td>
<td>Modulating actuator</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Return Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Hot Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Chilled Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Return Fan Static Pressure</td>
<td>AI</td>
<td>DPT-3, 0 to 1 inch</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Outdoor Airflow</td>
<td>AI</td>
<td>AFMS-3 cfm output</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Outdoor Air Temperature</td>
<td>AI</td>
<td>AFMS-3 temperature output</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>AI</td>
<td>TS-1B across filter bank</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td>–</td>
<td>60 min</td>
<td>F</td>
</tr>
<tr>
<td>Return Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
</tbody>
</table>
### 6. Dedicated Outdoor Air VAV Air Handler

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Commisioning</th>
<th>Continuous</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Fan 1 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan 2 Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Supply fan high static alarm reset</td>
<td>DO</td>
<td>Dry contact to 120V or 24V control circuit – see control sequences for details</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Hot Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Chilled Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Supply Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Outdoor Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td>–</td>
<td>60 min</td>
<td>F</td>
</tr>
<tr>
<td>Supply Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min</td>
<td>15 min</td>
<td>HH</td>
</tr>
<tr>
<td>Duct Static Pressure</td>
<td>AI</td>
<td>DPT-3A, 0 to 2 inches</td>
<td>1 min</td>
<td>15 min</td>
<td>F</td>
</tr>
</tbody>
</table>

### 7. Single Zone VAV Air Handler

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Commisioning</th>
<th>Continuous</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Fan Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
<td>–</td>
</tr>
<tr>
<td>Economizer Dampers</td>
<td>AO</td>
<td>Modulating actuator, linked to both return air and outdoor air parallel blade dampers</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Hot Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
<tr>
<td>Chilled Water Control Valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
<td>–</td>
</tr>
</tbody>
</table>
| Description               | Type | Device                                         | Trend Logging | Calibra-
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th>Commissioning</th>
<th>tion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>AI</td>
<td>TS-1B</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td>–</td>
<td>60 min</td>
</tr>
<tr>
<td>Supply Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

**8. 2-Pipe Variable Speed Fan-Coil**

| Description               | Type | Device                                         | Trend Logging | Calibra-
|                          |      |                                               | Commissioning | tion |
|                          |      |                                               | Continuous    |      |
| Fan on/off               | DO   | May be deleted if 0-10Vdc to ECM less than 2V shuts off fan | COV           | COV  |
| Fan speed                | AO   | 0-10Vdc to ECM                                | 1 min         | 15 min |
| CHW valve signal         | AO   | 2-way valve                                   | 1 min         | 15 min |
| Supply fan status        | DI   | CS-1                                          | COV           | COV  |
| Supply air temperature   | AI   | TS-1A                                         | 1 min         | 15 min |
| Zone Temperature         | AI   | TS-3x (see Paragraph Error! Reference source not found.). | 1 min         | 15 min |
| Local Override           | DI   | TS-3x – where applicable                      | COV           | COV  |
| Window switch            | DI   | WS (where indicated on Drawings)              | COV           | COV  |
| Zone Temperature Setpoint Adjustment | AI | TS-3x – where applicable (see Paragraph Error! Reference source not found.). | 15 min       | 60 min |
| Zone Temperature         | AI   | TS-3x (see Paragraph Error! Reference source not found.). | 1 min         | 15 min |
| Zone CO2 Concentration   | AI   | TS-3x (see Paragraph Error! Reference source not found.). | 5 min         | 15 min |

**9. Packaged Single Zone AC Units/Heat Pumps**
### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Start Fan</td>
<td>DO</td>
<td>Dry contact to contactor on control panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Cooling stages</td>
<td>Multiple DOs</td>
<td>See AC/HP unit schedule and submittals for quantity</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Heating stages</td>
<td>Multiple DOs</td>
<td>See AC/HP unit schedule and submittals for quantity</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply fan status</td>
<td>DI</td>
<td>Current switch</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Zone Temperature</td>
<td>AI</td>
<td>TS-3A</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

10. Packaged VAV AC Unit

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Start/stop</td>
<td>DO</td>
<td>Hard wired (dry contact to 24V control circuit)</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

11. Toilet Exhaust Fan

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Fan Start/Stop</td>
<td>DO</td>
<td>Dry contact to 120V starter control circuit</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fan Status</td>
<td>DI</td>
<td>CS-1</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

12. Air-Cooled Series Chiller Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>CH-1 on/off</td>
<td>DO</td>
<td>Connect to chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CH-2 on/off</td>
<td>DO</td>
<td>Connect to chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start CHP-1</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start CHP-2</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>CH-1 bypass valve</td>
<td>DO</td>
<td>2-position butterfly valve, line size</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>
### 13. 2-Pipe and 4-Pipe Air-Source Heat Pump/Chiller Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
<td></td>
</tr>
<tr>
<td>HRHP-1 cooling on/off</td>
<td>DO</td>
<td>Connect to 4-pipe HP/chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HRHP-1 heating on/off</td>
<td>DO</td>
<td>Connect to 4-pipe HP/chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HPCH-1 on/off</td>
<td>DO</td>
<td>Connect to 2-pipe HP/chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HPCH-1 mode</td>
<td>DO</td>
<td>Connect to 2-pipe HP/chiller heat/cool mode contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HPCH-2 on/off</td>
<td>DO</td>
<td>Connect to 2-pipe HP/chiller enable contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HPCH-2 mode</td>
<td>DO</td>
<td>Connect to 2-pipe HP/chiller heat/cool mode contact on chiller panel</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start HWP-1</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start HWP-2</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start CHWP-1</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start CHWP-2</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HPCH-1 changeover valves</td>
<td>DO</td>
<td>2-position 2-way valves, line size, spring return</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>
### ADDENDUM NO. 1

5036004
D-4014 Diablo Valley College P/K Complex

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibrations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>HPCH-2 changeover valves</td>
<td>DO</td>
<td>2-position 2-way valves, line size, spring return</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HWP speed</td>
<td>AO</td>
<td>Connect to VFD Speed on HWP-1, 2</td>
<td>1 min</td>
<td>5 min</td>
</tr>
<tr>
<td>CHP speed</td>
<td>AO</td>
<td>Connect to VFD Speed on CHP-1, 2</td>
<td>1 min</td>
<td>5 min</td>
</tr>
<tr>
<td>HW supply flow</td>
<td>Al</td>
<td>FM-1 (connected to BTU-1 auxiliary output)</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>CHW supply flow</td>
<td>Al</td>
<td>FM-1 (connected to BTU-1 auxiliary output)</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>HW differential pressure</td>
<td>Al</td>
<td>DPT-1, 0 to 20 psi, located at end of piping system</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>HW system gauge pressure</td>
<td>Al</td>
<td>PT-1, 0 to 60 psi (located near expansion tank)</td>
<td>15 min</td>
<td>1 hr</td>
</tr>
<tr>
<td>CHW differential pressure</td>
<td>Al</td>
<td>DPT-1, 0 to 20 psi, located at end of piping system</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>CHW system gauge pressure</td>
<td>Al</td>
<td>PT-1, 0 to 60 psi (located near expansion tank)</td>
<td>15 min</td>
<td>1 hr</td>
</tr>
</tbody>
</table>

### 14. Radiant Water Zone Manifold

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibrations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Manifold Flow Valve</td>
<td>DO</td>
<td>2-position 2-way valve</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Slab temperature</td>
<td>AI</td>
<td>TS-2B. Mount in floor box between radiant piping</td>
<td>1 min</td>
<td>10 min</td>
</tr>
<tr>
<td>Zone Temperature (provide only if the radiant manifold zone is not also served by an airside VAV zone(s))</td>
<td>AI</td>
<td>TS-3A</td>
<td>1 min</td>
<td>10 min</td>
</tr>
</tbody>
</table>

### 15. Radiant Water Loops

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibrations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Pump Start/Stop</td>
<td>DO</td>
<td>Connect to contactor or Motor Starter</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HW/TCHW Changeover Valve</td>
<td>DO</td>
<td>2-position 2-way valves with end switches, 1 control point to power all valves; see schematics</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>
# ADDENDUM NO. 1

## BUILDING AUTOMATION SYSTEMS

### Description | Type | Device | Trend Logging | Calibrations
--- | --- | --- | --- | ---

| | | | Commissioning | Continuous |
| --- | --- | --- | | |
| Pump Status | DI | CS-1 | COV | COV |
| Modulating HW/TCHW Control Valve Command | AO | Modulating 2-way valve with end switches sized per design flow rates, 1 control point for both; see schematics | 1 min | 10 min |
| Loop return temperature | AI | TS-2B | 1 min | 10 min |
| Loop supply temperature | AI | TS-2B | 1 min | 10 min |

### Description | Type | Device | Trend Logging | Calibrations
--- | --- | --- | --- | ---

| | | | Commissioning | Continuous |
| --- | --- | --- | | |
| DHW-1 System Recirculation Pumps Start/Stop | DO | Line voltage contact to pump power circuit | COV | COV |
| DHW-2 System Recirculation Pumps Start/Stop | DO | Line voltage contact to pump power circuit | COV | COV |
| DHW-1 Supply Temperature | AI | TS-2A | 5 min | 15 min |
| DHW-2 Supply Temperature | AI | TS-2A | 5 min | 15 min |
| DHW-1 System Recirculation Pump Status | DI | CS-1 | COV | COV |
| DHW-2 System Recirculation Pump Status | DI | CS-1 | COV | COV |
| DHW-1 heater Alarm | DI | Install relay wired downstream of DHW heater safeties with NC relay contact wired as alarm input. | COV | COV |
| DHW-2 heater Alarm | DI | Install relay wired downstream of DHW heater safeties with NC relay contact wired as alarm input. | COV | COV |

16. Domestic Water Heaters (gas, electric, or heat pump)

17. Domestic Hot Water Generator from Heating HW
### Addendum No. 1

**5036004**

**Building Automation Systems**

**PART 3 EXECUTION**

#### 3.1 Installation - General
- Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details indicated on Drawings.
- Coordinate Work and Work schedule with other trades prior to construction.
- Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

#### 3.2 Delivery, Storage, and Handling

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### 18. Hot Water and Chilled Water Plant Connection

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Trend Logging

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Tag</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commisioning</td>
<td>Continuous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.

B. Store equipment and materials inside and protect from weather.

3.3 Identification

A. General

1. Manufacturers’ nameplates and UL or CSA labels to be visible and legible after equipment is installed.

2. Identifiers shall match record documents.

3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring and Tubing

1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2 inches of termination with the BAS address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3. All pneumatic tubing shall be labeled at each end within 2 inches of termination with a descriptive identifier.

C. Equipment and Devices

1. Valve and damper actuators: None required.

2. Sensors: Provide 1-inch x 3 inches x 1/8 inches black micarta or lamacoid labels with engraved white lettering, ¼ inches high. Indicate sensor identifier and function (for example “CHWS Temp”).

3. Panels

   a. Provide 2 inches x 5 inches 1/8 inches black micarta or lamacoid labels with engraved white lettering, ½ inches high. Indicate panel identifier and service.

   b. Provide permanent tag indicating the electrical panel and circuit number from which panel is powered.

4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.4 Cutting, Coring, Patching and Painting

A. Provide canning for openings in concrete walls and floors and other structural elements prior to their construction.

B. Penetrations through rated walls or floors shall be filled with a listed material to provide a code compliant fire-stop.

C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating
cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.5 Cleaning
A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and legally disposed of.

B. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the Owner’s Representative.

C. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

D. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.6 Controllers
A. General
1. Install systems and materials in accordance with manufacturer’s instructions, specifications roughing-in drawings and details indicated on Drawings.

2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.

   a. Global points such as outdoor air temperature
   b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants
   c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones

3. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

B. Controller Application Categories
1. Controllers shall comply with the application table below (X under controller type indicates acceptable controller type).

<table>
<thead>
<tr>
<th>Application Category</th>
<th>Examples</th>
<th>Acceptable Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Monitoring of variables that are not used in a control loop,</td>
<td>ASC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Application Category</td>
<td>Examples</td>
<td>Acceptable Controller</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td>sequence logic, or safety, such as status of sump pumps or associated float switches, temperatures in monitored electrical rooms.</td>
<td>ASC</td>
</tr>
<tr>
<td>1</td>
<td>Miscellaneous heaters Constant speed exhaust fans and pumps</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Fan Coil Units Terminal Units (such as VAV Boxes) Unitary AC and HP units</td>
<td>X</td>
</tr>
</tbody>
</table>
| 4                    | Air Handling Units Central Hot Water Plant  
“Fast” Lab Zone –Hood Dominated Air-Cooled Chilled Water Plant                           | X    | (note 1) | X   |
| 5                    | Water-Cooled Chilled Water Plant                                                                                                        | X    |      |     |

Notes:

1. (1) Controller may be used only if all control functions and physical I/O associated with a given unit resides in one AAC/ASC

2. ASC Installation
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

3. AAC and BC Installation
   a. AACs/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
b. AACs/BCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

3.7 Communication Devices
   A. General
      1. Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details indicated on Drawings.
      2. Provide all interface devices and software to provide an integrated system.
   B. LANID and LAN Routers
      1. Provide as required
      2. Connect networks to both sides of device
      3. Thoroughly test to ensure proper operation
      4. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.
   C. Gateways and Routers to Equipment Controllers
      1. Wire to networks on both sides of device.
      2. Thoroughly test each point to ensure that mapping is accurate.
   D. External Communications
      1. Provide an Ethernet second port on the CSS to which the Owner can connect their Owner IT LAN (intranet), by others. Contractor shall coordinate with the Owner’s Representative to establish an IP address and communications parameters to assure proper operation. This connection shall also provide access to Internet through Owner’s firewall to Internet Services Provider procured by Owner.

3.8 Control Air Tubing
   A. Sensor air tubing shall be sized by the Contractor.
   B. All control air piping shall be concealed except in equipment rooms or unfinished areas.
   C. Installation methods and materials
      1. Concealed and Inaccessible: Use copper tubing or FR plastic in metal raceway. Exception: Room thermostat drops in stud walls in areas with lay-in ceiling may be FR plastic tubing.
      2. Concealed and Accessible tubing (including ceiling return air plenums) shall be copper tubing or FR plastic tubing, subject to the following limitations
         a. FR tubing shall be enclosed in metal raceway when required by local code.
b. Quantity of FR tubing per cubic foot of plenum space shall not exceed manufacturer’s published data for Class 1 installation.

3. Exposed to view or damage: Use hard-drawn copper or FR plastic in metal raceway.
   a. Where copper tubing is used, a section 12 inches or less of FR plastic tubing is acceptable at final connection to control device.

D. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum 1-inch sleeves, extended 6 inches above floors and 1 inch below bottom surface of slabs.

E. Pneumatic tubing shall not be run in raceway containing electrical wiring.

F. Where FR tubing exits the end of raceway or junction box, provide a snap-in nylon bushing. Where pneumatic tubing exits control panels, provide bulkhead fittings. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.

G. All tubing shall be number coded on each end and at each junction for easy identification.

H. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.

I. Piping above suspended ceilings shall be supported from or anchored to structural members or other piping or duct supports. Tubing shall not be supported by or anchored to electrical raceways or ceiling support systems.

J. Brass-barbed fittings shall be used at copper-to-FR tubing junctions. Plastic slipped-over copper tubing is not acceptable.

K. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.9 Control Power

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section unless specifically indicated on Division 26 Drawings or Specifications.
   1. See Division 26 Electrical Drawings for power locations pre-allocated for BAS system.
   2. Coordinate with Division 26 during shop drawing development for final connection location.

B. General requirements for obtaining power include the following:
   1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.
   2. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the
equipment's control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).

C. Unless transformers are provided with equipment as specified in related Division 23 and 26 equipment Sections, Contractor shall provide transformers for all low voltage control devices including non-powered terminal units such as cooling-only VAV boxes and VAV boxes with hot water reheat. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

D. Power line filtering. Provide transient voltage and surge suppression for all workstations and BCs either internally or as an external component.

3.10 Control and Communication Wiring

A. Control and Signal Wiring


2. Line Voltage Wiring

   a. All line-voltage wiring shall meet NEC Class 1 requirements.

   b. All Class 1 wiring shall be installed in UL Listed approved raceway per NEC requirements and shall be installed by a licensed electrician.

   c. Class 1 wiring shall not be installed in raceway containing pneumatic tubing.

3. Low Voltage Wiring

   a. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

   b. Class 2 wiring shall be installed in UL Listed approved raceway as follows:

      1) Where located in unconcealed or inaccessible locations, such as:

         a) Equipment rooms

         b) Exposed to weather

         c) Exposed to occupant view

         d) Inaccessible locations such as concealed shafts and above inaccessible ceilings

      2) Class 2 wiring shall not be installed in raceway containing Class 1 wiring.

   c. Class 2 wiring need not be installed in raceway as follows:

      1) Where located in concealed and easily accessible locations, such as:

         a) Inside mechanical equipment enclosures and control panels

         b) Above suspended accessible ceilings (e.g. lay-in and spline)

         c) Above suspended drywall ceilings within reach of access panels throughout

         d) In shafts within reach of access panels throughout

         e) Nonrated wall cavities
2) Wiring shall be UL Listed for the intended application. For example, cables used in floor or ceiling plenums used for air transport shall be UL Listed specifically for that purpose.

3) Wiring shall be supported from or anchored to structural members neatly tied at 10-foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.

4) Install wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

d. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

4. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

5. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.

6. Use coded conductors throughout with different colored conductors.

7. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

8. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.

9. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

10. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer’s recommendation and NEC requirements.

11. Include one pull string in each raceway 1 inch or larger.

12. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

13. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).

14. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

15. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
16. Terminate all control or interlock wiring.

17. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.

18. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inches electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.

19. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings per code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

20. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise indicated herein, wire to the NO contact except the following shall be wired to the NC contact:
   a. Hot water pumps

21. Hardwire Interlocks
   a. The devices referenced in this Section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.
   b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.
   c. Where multiple fans (or BAS DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.
   d. Provide for the following devices where indicated on Drawings or in Sequences of Operation:
      1) High discharge static pressure
      2) Low mixing plenum pressure

22. Shielded cable shield shall be grounded only at one end. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

B. Communication Wiring
   1. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted only if noise immunity is ensured. Contractor is fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
   2. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers’ installation recommendations for all communication cabling.
   3. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
4. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.

5. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

6. All runs of communication wiring shall be un-spliced length when that length is commercially available.

7. All communication wiring shall be labeled to indicate origination and destination data.

8. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable and Protector Grounding.

9. Power-line carrier signal communication or transmission is not acceptable.

3.11 Sensors and Miscellaneous Field Devices

A. Install sensors in accordance with the manufacturer’s recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Sensors used as controlled points in control loops shall be hardwired to the controller to which the controlled device is wired and in which the control loop shall reside.

D. Temperature Sensors

1. Room temperature sensors and thermostats shall be installed with back plate firmly secured to the wall framing or drywall anchors.

   a. For sensors mounted in exterior walls or columns, use a back plate insulated with foam and seal all junction box openings with mastic sealant.

   b. For sensors on exposed columns, use Wiremold or equal enclosures that are the smallest required to enclose wiring (e.g. Wiremold 400 BAC or equal) and Wiremold or equal junction boxes that are the narrowest required to enclose the temperature sensor and wiring connections (e.g. Wiremold 2348S/51 or equal). Color or raceway and boxes shall be per the architect; submit for approval prior to installation.

2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (such as mixed air sensors), access for filter removal shall be maintained.

4. Temperature sensors downstream of coils shall be located as far from the coil fins as possible, 6 inches minimum. Temperature sensors upstream of coils shall be a minimum of 6 inches away from the coil fins. No part of the sensor or its support elements or conduit shall be in contact with the coil, coil framing or coil support elements. Discharge temperature sensors on VAV boxes shall be mounted as far from the coil as possible but upstream of the first diffuser with the probe located as near as possible to the center of the duct both vertically and horizontally.
5. All pipe-mounted temperature sensors shall be installed in wells. For small piping, well shall be installed in an elbow into pipe length. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.

6. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO$_2$ sensors, and other room wall mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.

7. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to either
         a) Building pressure (high) signal of the building static pressure transmitter.
         b) Open to a conditioned space inside the building
         c) Open to the BAS panel in which the DPT is mounted provided the panel is inside the building envelope and not in an air plenum.
   c. High-pressure port of the pressure sensor
      1) Pipe to the duct using a static pressure tip located as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers.
      2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions.

2. Building Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.
   c. High-pressure port of the pressure sensor
1) Pipe to either
   a) Behind a BAS temperature sensor cover in an interior zone (provided sensor has openings to allow ambient air to freely flow through it)
   b) Wall plate sensor

2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

3. Filter Differential Pressure
   a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow.
   b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.

4. High/Low Static Pressure Safeties
   a. High static
      1) Install DPS-2 on side of supply air duct in accessible location.
      2) High port shall be open to supply air duct downstream of fan.
      3) Reference low port pressure shall be that at DP location.
   b. Low static
      1) Install DPS-2 inside or outside of mixed air plenum whichever is most accessible.
      2) Low port shall be open to mixed air plenum.
      3) Reference high port pressure shall be pressure on other side of mixed air plenum with the highest pressure, e.g. ambient pressure for systems with relief fans or non-powered relief, or relief air plenum for systems with return fans.

5. All pressure transducers, other than those controlling VAV boxes, shall be located where accessible for service without use of ladders or special equipment. If required, locate in field device panels and pipe to the equipment monitored or ductwork.

6. The piping to the pressure ports on all pressure transducers (both air and water) shall contain a capped test port located adjacent to the transducer.

7. Piping differential pressure transducers shall have one of the following:
   a. Five valve manifold, brass, two valves to allow removal of sensor without disrupting the hydronic system, an equalizing valve to allow the sensor to be zeroed and to prevent sensor from experiencing full static (as opposed to differential) where, and two valves used as air vents that also can be used as test plugs for calibration.
   b. For sensors using two separate sensors, install test plugs on each connection for calibration and also used as vents.
F. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running. For pumps, adjust so that pump indicates off if valve is closed while pump is running.

G. Airflow Measuring Stations: Install per manufacturer’s recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

H. Fluid Flow Meters: Install per manufacturer’s recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer’s startup and commissioning recommendations. Complete all manufacturer’s startup documentation and include this in pre-functional commissioning report.

I. Actuators

1. Type: All actuators shall be electric.

2. Mount and link control damper actuators per manufacturer’s instructions.

3. Dampers
   a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturer’s instructions to achieve same effect.
   
   b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

   c. Provide all mounting hardware and linkages for actuator installation.

4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, mount the valve so that the position indicator is visible from the floor or other readily accessible location. However, do not install valves with stem below horizontal or down. The preferred location for the valve and actuator is on lowest point in the valve train assembly for ease of access and inspection. If this is on the coil supply piping, the control valve may be located there even if schematics (and standard practice) show valves located on the coil return piping. This comment applies to both 2-way valves and 3-way valves (which would become diverting valves rather than mixing valves in this location).

3.12 Software Installation

A. System Configuration

1. Thoroughly and completely configure BAS system software, supplemental software, network software etc. on OWS, POTs, and servers.

B. Point Structuring and Naming
1. The intent of this Paragraph is to require a consistent means of naming points across the BAS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.

2. Point Summary Table
   a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.
   b. With each schematic, provide a Point Summary Table listing
      1) Building number and abbreviation
      2) System type
      3) Equipment type
      4) Point suffix
      5) Full point name (see Point Naming Convention Paragraph)
      6) Point description
      7) Ethernet backbone network number
      8) Network number
      9) Device ID
      10) Device MAC address
      11) Object ID (object type, instance number)
      12) Engineering units
      13) Device make and model number; include range of device if model number does not so identify.
      14) Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).
   c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).
   d. Coordinate with the Owner’s representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.
   e. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

3. Point Naming Convention
   a. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.
b. Format:


2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature (sample)

<table>
<thead>
<tr>
<th>Building</th>
<th>Category</th>
<th>System</th>
<th>Equipment Tag (from equipment schedules)</th>
<th>Component</th>
<th>Property</th>
<th>Typical units</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Science</td>
<td>ELCT</td>
<td>Lighting</td>
<td>SWITCH</td>
<td>Command</td>
<td>On/off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plug</td>
<td>PHOTO</td>
<td>Status</td>
<td>On/off</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generator</td>
<td>CB</td>
<td>Light</td>
<td>Footcandles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc</td>
<td>CWS</td>
<td>Power</td>
<td>Watts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC</td>
<td>Airhandling</td>
<td>CWR</td>
<td>Voltage</td>
<td>Volts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exhaust</td>
<td>HWS</td>
<td>Current</td>
<td>Amps</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heatplant</td>
<td>HWR</td>
<td>ValvePos</td>
<td>%open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coolplant</td>
<td>CHWS</td>
<td>DamperPos</td>
<td>%open</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Misc</td>
<td>CHWR</td>
<td>Temperature</td>
<td>°F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLMB</td>
<td>Domwater</td>
<td>OA</td>
<td>Humidity</td>
<td>%RH</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air</td>
<td>SA</td>
<td>Pressure</td>
<td>Psig, &quot;H₂O</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Natgas</td>
<td>RA</td>
<td>Flow</td>
<td>Cfm, gpm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>N2</td>
<td>EA</td>
<td>Energy</td>
<td>Btu</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>O2</td>
<td>GAS</td>
<td>Speed</td>
<td>%, Hz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Irrigation</td>
<td>FLUID</td>
<td>Signal</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MISC</td>
<td>Weather</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Device Addressing Convention

a. BACnet network numbers and Device Object IDs shall be unique throughout the network.

b. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner to ensure there are no duplicate BACnet device instance numbers.

c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner: VVVNN, where: VVV = 0-999 for BACnet Vendor ID, NN = 00 - 99 for building network.

d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner: VVNNDD , where: VVV = number 0 to 999 for BACnet Vendor ID , NN = 00 - 99 for building network, DD = 01-99 for device address on a network.
e. Coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.

f. Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

5. I/O Point Physical Description

a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:
   1) The device manufacturer and model number. Include range of device if model number does not so identify.
   2) For space sensors, include room number in which sensor is located.

C. Point Parameters

1. Provide the following minimum programming for each analog input
   a. Name
   b. Address
   c. Scanning frequency or COV threshold
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
   f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
   g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.

2. Provide the following minimum programming for each analog output
   a. Name
   b. Address
   c. Engineering units
   d. Offset calibration and scaling factor for engineering units
   e. Output Range
   f. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
d. Debounce time delay

e. Message and alarm reporting as specified

f. Reporting of each change of state, and memory storage of the time of the last change of state

g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

4. Provide the following minimum programming for each digital output

a. Name

b. Address

c. Output updating frequency

d. Engineering units (on/off, open/closed, freeze/normal, etc.)

e. Direct or Reverse action selection

f. Minimum on-time

g. Minimum off-time

h. Status association with a DI and failure alarming (as applicable)

i. Reporting of each change of state, and memory storage of the time of the last change of state.

j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

k. Default value to be used when the normal controlling value is not reporting.

D. Site-Specific Application Programming

1. All site-specific application programming shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:

a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.

b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.

c. Programs are thoroughly debugged before they are installed in the field.

2. Massage and tune application programming for a fully functioning system. It is the Contractor's responsibility to request clarification on sequences of operation that require such clarification.

3. All site-specific programming shall be fully documented and submitted for review and approval

a. Prior to downloading into the panel

b. At the completion of functional performance testing, and

c. At the end of the warranty period
4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the Owner and shall remain on the workstations/servers at the completion of the Project.

E. Graphic Screens

1. All site-specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.

2. Schematics of MEP systems
   a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided on Drawings.
   b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
   c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.
   d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

3. Displays shall show all points relevant to the operation of the system, including setpoints.

4. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

5. Show weather conditions (local building outside air temperature and humidity) in the upper left-hand corner of every graphic.

6. CAD Files: The contract document drawings will be made available to the Contractor in AutoCAD format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However, the Owner does not guarantee the suitability of these drawings for the Contractor’s purpose.

7. Provide graphics for the following as a minimum
   a. Building homepage: Background shall be a building footprint, approximately to scale, oriented as shown on the campus homepage. Include links to each floor and mechanical room/area, and to summary graphics described below. Include real-time site utility data such as electric meter building electrical demand, domestic cold-water flow, and natural gas demand shown roughly on the map where the utilities connect to the site.
   b. Electricity demand limiting
1) Demand limit. Include entries for sliding window interval and a table of On-Peak or Partial-Peak demand time periods with three adjustable demand level limits for each and adjustable deadband.

2) Electricity demand calculation. For each month, show actual peak kW and kWh for each time-of-day rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data.

c. Each occupied floor plan, to scale

1) HVAC: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone’s actual comfort condition changes. In each zone, provide links to associated terminal equipment.

2) If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

d. Each equipment floor/area plan: To scale, with links to graphics of all BAS controlled/monitored equipment.

e. Each air handler and fan-coil: Provide link to associated HW and CHW plants where applicable.

f. Each trim & respond reset: Next to the display of the setpoint that is being reset, include a link to page showing all trim & respond points (see Guideline 36) plus the current number of requests, current setpoint, and status indicator point with values “trimming,” “responding,” or “holding.” Include a graph of the setpoint trend for the last 24 hours. Trim & respond points shall be adjustable from the graphic except for the associated device.

g. Each zone terminal:

1) Provide link to associated air handling unit where applicable and to floor plan where terminal is located.

2) Include supply air temperature from AHU serving terminal unit.

3) Include a non-editable graphic (picture) showing the design airflow setpoints from the design drawings adjacent to the editable airflows setpoints. The intent is that the original setpoints be retained over time despite “temporary” adjustments that may be made over the years.

h. Electrical power monitoring system: Show a schematic of the electrical system based on one-line diagrams with meter current kW reading and month-to-date kWh shown in actual locations. Power flow shall change on the diagram (by changing line color or width) to show which power line is active.

i. Central plant equipment including chilled water system, cooling tower system, hot water system, steam system, generators, etc.: The flow path shall change
on the diagram (by changing piping line color or width) to show which piping has active flow into each ASHP, ASHP, tower, etc. as valve positions change.

j. Summary graphics: Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment. Include hyperlinks to each zone imbedded in the zone tag:

1) Air handling units: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; outdoor air and return air damper position; coil valve positions; etc. (all key operating variables); Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (if HW coil)

2) VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; damper position; HW valve position (reheat boxes); supply air temperature (reheat boxes); supply air temperature setpoint (reheat boxes); CO2 concentration and CO2 loop output (where applicable); Fan start/stop command, speed, and status (fan-powered); Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (HW reheat); Heating Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct); Heating SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier (dual duct).

3) Laboratory VAV Zone terminal units: operating mode; airflow rate; airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; damper position; HW valve position; CHW valve position; supply air temperature; supply air temperature setpoint; Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

4) Laboratory Air Systems: operating mode; supply airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; general exhaust airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; hood exhaust airflow rate, airflow rate setpoint, damper position, Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; any hood alarm.
5) Fan-coil units: operating mode; zone temperature; active heating setpoint; active cooling setpoint; supply air temperature; supply air temperature setpoint (where applicable); fan status; fan speed (where applicable); HW/CHW valve position; Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

6) Electrical meters and switches: Volts, current, kW, switch positions.

k. For all equipment with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.

l. For all equipment with lead/lag or lead/standby operation specified, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead switching by the operator per Paragraph 3.13B.4.

m. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.

n. All other BAS controlled/monitored equipment.

o. On all system graphics, include a “note” block that allows users to enter comments relevant to system operation.

p. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

F. Alarm Configuration

1. Program alarms and alarm levels per Sequence of Operations.

2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).

3. For initial setup, Contractor shall configure alarms as follows:

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality</td>
<td>Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
<td>Not Critical</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>Required</td>
<td>Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Acknowledgement of Return to Normal</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Email to building engineer(s)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
4. At the end of commissioning and then again at the end of the warranty period, fully synchronize the database on this POT with that on the CSS.

3.13 Sequences of Operation

A. Sequences herein reference ASHRAE Guideline 36-2018 which is generic, and cannot possibly account for finer details of every piece of equipment or project. Contractor is responsible for comprehending the references, however the detail in this document take precedence where conflicts could arise.

B. General

1. Comply with ASHRAE Guideline 36-2018 Section 5.1 General to the best extent possible.

2. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be included as a part of Submittal Package 2.

3. Include costs for minor program modifications if required to provide proper performance of the system.

4. Equipment Staging and Rotation

a. Parallel devices shall be lead/lag or lead/standby rotated to maintain even wear.

b. Two runtime points shall be defined for each device:

   1) Lifetime Runtime: The cumulative runtime of the device since device start-up. This point shall not be readily resettable by operators.

   2) Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.

   c. Lead/lag devices: Unless otherwise noted, parallel staged devices (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours as determined by Staging Runtime is made the last stage device and the one with the least number of hours is made the lead stage device.

   This strategy effectively makes it such that devices are not "hot swapped", e.g. a pump would not be started and another stopped during operation just for runtime equalization.
For example, assume there are two devices and only one is on, but the operating device has exceeded the run hours of the disabled device. The devices will not rotate positions until either a stage up or down occurs. If the plant stages up, then both devices will be on and lead/lag position will switch; when the plant next stages down, the former lead device with more run hours will then turn off.

Expanding further, for a plant with three devices, if all three are off or all are on, the staging order will simply be based on run hours from lowest to highest. If two devices are on, the one with more hours will be set to be stage 2 while the other is set to stage 1; this may be the reverse of the operating order when the devices were started. If two devices are off, the one with the more hours will be set to be stage 3 while the other is set to stage 2; this may be the reverse of the operating order when the devices were stopped.

Example with three pumps:
1. P-1 (1000 hours), 2 (950 hours), and 3 (900 hours) are all off. Staging logic makes lead/lag order: 3, 2, 1
2. P-3 starts. Logic does not change its order since it is on by itself.
3. P-3 runs for 51 hours. Since it is on and others off, the lead/lag order does not change. It can run this way indefinitely and the order does not change.
4. There is then a stage-up command. P-2 (the next in lead/lag order) is started. So both P-2 and P-3 are on. P-3 now as more run hours than P-2. So the Lead/lag order changes to: 2, 3, 1.
5. These two pumps run another 51 hours. Run times are P-1 (1000 hours), P-2 (1001) and P-3 (1002). No changes are made to lead/lag order because P-1 is off alone.
6. There is a stage down command. P-2 is now lead so it stays on. P-3 is shut off. The order for the two off pumps is now adjusted because P-1 has fewest run hours. lead/lag order is now: 2, 1, 3
7. P-2 runs for 100 more hours. It now has the longest runtime, but order does not change since it is on alone. Order is still 2, 1, 3
8. There is a stage down or plant-off command. P-2 shuts off. Run times are P-1 (1000 hours), P-2 (1101) and P-3 (1002). Since all are off, order is switched to: 1, 3, 2

**d. Lead/standby devices:**

1) Unless devices run continuously, parallel devices that are 100% redundant shall be lead/standby alternated when more than one device is off so that the device with the most operating hours as determined by Staging Runtime is made the last stage device and the one with the least number of hours is made the earlier stage device.

2) If devices run continuously, lead/standby positions shall switch at an adjustable frequency (e.g. every 14 days) based on Staging Runtime;
standby device shall first be started and proven on before former lead device is changed to standby and shut off.

a) Variable speed pumps shall have a deceleration rate of 1 Hz/second or slower set in BAS logic when disabled to prevent nuisance trips of operating devices (e.g. chillers).

e. Exceptions to Lead/lag and Lead/standby rotation

1) Operators with appropriate access level shall be able to manually command staging order via software points, but not overriding the In Alarm or Hand Operation logic below.

a) Faulted Devices: A faulted device is any device commanded to run that is either not running or unable to perform its required duty. If an operating device has any fault condition described subsequently, a Level 2 alarm shall be generated and a response shall be triggered as defined below.

1. Fans and Pumps
   a. Status point not matching its on/off point for 3 seconds after a time delay of 15 seconds when device is commanded on.

2. Chillers
   a. Shutdown alarm condition either through network or hardwired alarm contact, or
   b. Chiller is manually shut off as indicated by the status of the Local/Auto switch from chiller gateway, or
   c. Chiller status remains off 5 minutes after command to start, or
   d. If provided, CHW isolation valve feedback indicates valve is not open 90 seconds after device is commanded open, or
   e. If provided, CW isolation valve feedback indicates valve is not open 90 seconds after device is commanded open.
   f. For 15 minutes chilled water return temperature has been at least 5°F above the CHWST setpoint, and delta-T across the chiller, as determined based on the difference between chilled water return temperature and chilled water supply temperature measured at the chiller (i.e. not common CHWST), has been less than 3°F.

3. Cooling Towers
   a. Tower fan has failed as defined above, or
   b. If provided, inlet end switch indicates valve is not open 90 seconds after device is commanded open, or
   c. If provided, outlet end switch indicates valve is not open 90 seconds after device is commanded open.

b) Upon identification of a fault condition:

1. For fans and pumps:
a. The next commanded OFF device in the staging order, Device “B”, shall be commanded ON while alarming Device “A” remains commanded ON.

b. If Device B fails to prove status (i.e. it also goes into alarm), it shall remain commanded on and the preceding step shall be repeated until the quantity of devices called for by the lead/lag logic have proven on.

c. When either the required number of devices proves on or all devices are commanded on, set alarming devices to the last positions in the lead/lag staging order sequenced reverse chronologically (i.e. the device that alarmed most recently is sent to last position).

d. Staging order of non-alarming devices shall follow the even wear logic. A device in alarm can only automatically move up in the staging order if another device goes into alarm.

e. Devices in alarm shall run if so called for by the lead/lag staging order and present stage.

2. For chillers:

a. The next commanded OFF device in the staging order, Device “B”, shall be commanded ON while alarming Device “A” is commanded OFF and set to the last position in the lead/lag staging order.

b. If Device B fails to prove status (i.e. it also goes into alarm), repeat the preceding step until the quantity of devices called for by the lead/lag logic have proven on.

c. Staging order of non-alarming devices shall follow the even wear logic. A device in alarm can only automatically move up in the staging order if another device goes into alarm.

d. Devices in alarm shall run if so called for by the lead/lag staging order and present stage.

2) Hand Operation: If a device is on in Hand (e.g., via an HOA switch or local control of VFD), the device shall be set to the lead device and a Level 4 alarm shall be generated. The device will remain as lead until the alarm is reset by the operator. Hand operation is determined by:

a) Fans and Pumps

1. Status point not matching its on/off point for 15 seconds when device is commanded off.

5. Occupancy Status

a. Occupancy status of all spaces shall be via the Lighting Control BACnet interface.

b. In case of the network connection with the Lighting Controls is lost:
1) For all other zones, occupancy status shall default to “occupied” if the Zone Group is in Occupied Mode and “unoccupied” for any other Zone Group Mode.

2) During occupiable hours use CO2 zones use CO2 sensor. For all other zones use temperature sensor for occupancy status.

6. VAV Box Controllable Minimum

   a. This section is used to determine the lowest possible VAV box airflow setpoint (other than zero) allowed by the controls (Vm) used in VAV box control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface.

   b. Option 1: If the VAV box controller can control to 0.004”, the minimum setpoint Vm shall be determined from the table below if the VAV box manufacturer is listed:

<table>
<thead>
<tr>
<th>Inlet</th>
<th>Titus</th>
<th>Krueger</th>
<th>Price</th>
<th>MetalAire High Gain</th>
<th>ETI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>35</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>55</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>90</td>
<td>90</td>
<td>95</td>
<td>85</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>120</td>
<td>130</td>
<td>135</td>
<td>110</td>
<td>130</td>
</tr>
<tr>
<td>14</td>
<td>190</td>
<td>175</td>
<td>195</td>
<td>155</td>
<td>180</td>
</tr>
<tr>
<td>16</td>
<td>245</td>
<td>230</td>
<td>260</td>
<td>210</td>
<td>235</td>
</tr>
<tr>
<td>24x16</td>
<td>455</td>
<td>445</td>
<td>490</td>
<td>N/A</td>
<td>415</td>
</tr>
</tbody>
</table>

   c. Option 2: The minimum setpoint Vm shall be determined per Guideline 36.

C. Electricity Demand Limiting

   1. Note: This demand section is generic in nature to get the building demand response “ready”. DDC contractor to provide software license for automated response in based bid. Owner responsibility to enrolled in demand response program direct with utility company.

   2. Base demand on power to entire building based on monitored Division 26 power meter.

   3. Sliding Window: The demand control function shall utilize a sliding window method selectable in increments of one minute, up to 60 minutes, 15-minute default.

   4. Demand Levels: Demand time periods shall be set up as per utility rate schedule. For each On-Peak or Partial-Peak period, three demand level limits can be defined. When the measured demand exceeds the limit, the Demand Limit Level switch for that level shall be set; when demand is less than 10%
(adjustable) below the limit for a minimum of 15 minutes, and the time is no longer within the On-Peak or Partial-Peak window, the switch shall be reset. These levels are used at the zone level (see Zone Control sequences) to shed demand.

5. In addition to setpoint reset logic triggered by Demand Levels as described below, include Demand Shed commands to the lighting control system via BACnet interface for each Demand Level. The response to each Demand Shed command shall be programmed into the lighting control system under Division 26.

D. Zones

1. Fully comply with ASHRAE Guideline 36-2018 Section 5.2 Generic Ventilation Zones.
   a. Use Title 24 for ventilation logic and ASHRAE+30% to meet LEED.
      1) Add the following to 5.2.1.4.2
   b. If no value is entered in VAV box schedules for Occupied Minimum Airflow Setpoint (Vmin), Vmin shall be set equal Zone-Abs-OA-min
   c. If no value is entered in VAV box schedule for Occupied Minimum Airflow Setpoint, assume Vmin = Vmax.
   d. Fully implement Time Averaged Ventilation (TAV) 5.2.2 and use it when VAV minimum, Vmin*, is below the lowest allowed by the controls (Vm).

2. Fully comply with ASHRAE Guideline 36-2018 Section 5.3 Generic Thermal Zones.
   a. Default setpoints:

<table>
<thead>
<tr>
<th>Zone type</th>
<th>Occupied</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat</td>
<td>Cool</td>
</tr>
<tr>
<td>VAV exterior</td>
<td>70°F</td>
<td>75°F</td>
</tr>
<tr>
<td>VAV interior</td>
<td>70°F</td>
<td>73°F</td>
</tr>
<tr>
<td>Electrical and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mechanical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDF/MDF</td>
<td>60°F</td>
<td>78°F</td>
</tr>
</tbody>
</table>

3. CO2 Setpoints
   a. California Title 24, all occupancy types: 1,000ppm
   b. Standard 62.1 CO2 setpoints for each zone with a CO2 sensor shall be scheduled on the drawings

E. Zone Groups

1. All terminal units must be placed in zone group associated with the AHU that serves it.
2. Contractor to submit zone groupings as part of submittal process.

3. Consult with Owner for all schedules. Use the following initial schedule:
   a. Weekday: 7am to 7pm
   b. SAT: 9am to 2pm
   c. SUN: off
   d. Holiday: off

3.1 VAV Terminal Unit with Reheat
A. See Generic Thermal Zones for setpoints, loops, control modes, alarms, etc.
B. See Generic Ventilation Zones for calculation of zone minimum outdoor airflow.
C. See for zone minimum airflow setpoints Vmin, zone maximum cooling airflow setpoint Vcool-max, zone maximum heating design airflow setpoint Vheat-max, and the maximum discharge air temperature rise above heating setpoint, MaxΔT.
1. Parameters (as applicable)
   a. Design Information (see VAV Box schedule):
      1) Vcool-max, zone maximum cooling airflow setpoint
      2) Vmin, zone occupied minimum airflow setpoint
      3) Vheat-max, zone maximum heating airflow setpoint
      4) Vocc-min, zone minimum outdoor airflow for occupants, per Title 24 prescribed airflow-per-occupant requirements
      5) Varea-min, zone minimum outdoor airflow for building area, per Title 24 prescribed airflow-per-area requirements
   b. Set the following:
      1) Zone maximum discharge air temperature above heating setpoint (MaxΔT) = 25°F
      2) The heating minimum airflow setpoint (Vheat-min) = 0

D. Active maximum and minimum setpoints shall vary depending on the Mode of the Zone Group the zone is a part of:

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>Occupied</th>
<th>Cool-down</th>
<th>Setup</th>
<th>Warm-up</th>
<th>Setback</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling maximum</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cooling minimum</td>
<td>Vmin*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minimum</td>
<td>Vmin*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Setpoint</td>
<td>Occupied</td>
<td>Cool-down</td>
<td>Setup</td>
<td>Warm-up</td>
<td>Setback</td>
<td>Unoccupied</td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>-----------</td>
<td>-------</td>
<td>-----------</td>
<td>-----------</td>
<td>------------</td>
</tr>
<tr>
<td>Heating minimum</td>
<td>Max(Vheat t-min, Vmin*)</td>
<td>Vheat-min</td>
<td>0</td>
<td>Vheat-max</td>
<td>Vheat-max</td>
<td>0</td>
</tr>
<tr>
<td>Heating maximum</td>
<td>Max(Vheat t-max, Vmin*)</td>
<td>Vheat-max</td>
<td>0</td>
<td>Vcool-max</td>
<td>Vcool-max</td>
<td>0</td>
</tr>
</tbody>
</table>

These sequences use different maximum airflow setpoints for heating and cooling. This “dual max” logic allows the minimum airflow setpoint to be lower than in a conventional sequence where the minimum airflow equals the heating airflow.

Heating is non-zero in Cool-down to allow for individual zones within a Zone Group that may need heating while the Zone Group is in Cool-down.

The Warm-up and Setback minimum setpoint is set to zero to ensure spaces that do not want heat during these modes receive no air; since the supply air temperature can be warm in these modes if the AHU has a heating coil, any minimum could cause overheating. The heating minimum is set to Vheat-max and the heating maximum is set to Vcool-max to provide faster response. This also ensures non-zero flow for the first half of the heating loop, avoiding instabilities.
E. Control logic is depicted schematically in figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.

![Diagram of control logic]

- **Supply Air Temperature Setpoint**
- **Heating Maximum**
- **Minimum airflow setpoint**
- **Cooling Maximum**

- **Heating PID Signal**
- **Cooling PID Signal**

**a)** When the zone is in the Cooling Mode, the Cooling Loop output shall be mapped to the airflow setpoint from the cooling maximum to the minimum airflow setpoints.

1. If supply air temperature from the air handler is greater than room temperature, cooling supply airflow setpoint shall be no higher than the minimum.

**b)** When the zone is in the Deadband Mode, the airflow setpoint shall be the minimum airflow setpoint.

**c)** When the zone is in the Heating Mode, the Heating Loop shall be mapped as follows:

1. From 0-33%, the Heating Loop output shall reset the discharge temperature from 50°F to 95°F.
2. From 33%-66%, if the supply air temperature is greater than the room temperature plus 5°F, the Heating Loop output shall reset the zone airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint.
3. From 66-100%, the Heating Loop output shall reset the discharge temperature from 95°F to 115°F.
d) The hot water valve shall be modulated using P+I loop to maintain the discharge temperature at setpoint. (Directly controlling HW valve off zone temperature PID loop is not acceptable.)
e) The VAV damper shall be modulated to maintain the measured airflow at setpoint.

A. Demand Based CO2 Control:
   1. See plans for applicable zones.
   2. Record ambient space CO2 during an unpopulated time.
   3. When the zone is in 200 ppm (adj) or less above ambient CO2, the zone cfm may drop to the area minimum indicate on the drawings.
   4. When the zone exceeds the 200 ppm (adj) above ambient threshold, the VAV will revert back to the cooling min CFM.
   5. When the zone exceeds 400 ppm (adj) above ambient
      a. use a P-only loop to begin resetting the VAV cfm higher to help influence the space CO2 to go back down. Max VAV cfm should correspond to a space CO2 level of 1800 ppm (adj).
      b. control the discharge air temperature to maintain space temperature setpoint. This is necessary to prevent over heating/cooling of the space.

F. Alarms
   1. Low airflow
      a. If the measured airflow is less than 70% of setpoint for 5 minutes while setpoint is greater than zero, generate a Level 3 alarm.
      b. If the measured airflow is less than 50% of setpoint for 5 minutes while setpoint is greater than zero, generate a Level 2 alarm.
      c. If a zone has an Importance-Multiplier of 0 for its static pressure reset Trim & Respond control loop, low airflow alarms shall be suppressed for that zone.
   2. Low discharge air temperature
      a. If heating hot water plant is proven on and the discharge air temperature is 8°C (15°F) less than setpoint for 10 minutes, generate a Level 3 alarm.
      b. If heating hot water plant is proven on and the discharge air temperature is 17°C (30°F) less than setpoint for 10 minutes, generate a Level 2 alarm.
      c. If a zone has an Importance-Multiplier of 0 for its Hot Water reset Trim & Respond control loop, low discharge air temperature alarms shall be suppressed for that zone.
   3. Airflow sensor calibration. If the fan serving the zone has been off for 10 minutes and airflow sensor reading is above 10% of the cooling maximum airflow setpoint, generate a Level 3 alarm.
   4. Leaking damper. If the damper position is 0% and airflow sensor reading is above 10% of the cooling maximum airflow setpoint for 10 minutes while the fan serving the zone is proven on, generate a Level 4 alarm.
5. Leaking valve. If the valve position is 0% for 15 minutes, discharge air temperature is above AHU SAT by 3°C (5°F), and the fan serving the zone is proven on, generate a Level 4 alarm.

G. Testing/Commissioning Overrides:
1. Force zone airflow setpoint to zero.
2. Force zone airflow setpoint to Vcool-max.
3. Force zone airflow setpoint to Vmin.
4. Force zone airflow setpoint to Vheat-max.
5. Force damper full closed/open.
6. Force heating to off/closed.
7. Reset request-hours accumulator point to zero (provide one point for each reset type listed below).

All hardware points can be overridden through the BAS. Each of the following points is interlocked so that they can be overridden together at a Zone Group level.

E.g., The CxA can check for leaking dampers by forcing all VAV boxes in a Zone Group closed and then recording airflow at the AHU.

H. System Requests
1. Static Pressure Reset Requests
   a. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 Requests,
   b. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 Requests,
   c. Else if the damper position is greater than 95%, send 1 Request until the damper position is less than 85%,
   d. Else if the damper position is less than 95%, send 0 Request.

3.2 Reheat Coil (only) Zone
   A. See for zone minimum airflow setpoints Vmin, zone maximum cooling airflow setpoint Vcool-max, zone maximum heating design airflow setpoint Vheat-max, and the maximum discharge air temperature rise above heating setpoint, MaxΔT.
   1. Parameters (as applicable)
      a. Design Information (see VAV Box schedule):
         1) Vcool-max, zone maximum cooling airflow setpoint
         2) Vmin, zone occupied minimum airflow setpoint
         3) Vheat-max, zone maximum heating airflow setpoint
         4) Vocc-min, zone minimum outdoor airflow for occupants, per Title 24 prescribed airflow-per-occupant requirements
5) Varea-min, zone minimum outdoor airflow for building area, per Title 24 prescribed airflow-per-area requirements

b. Set the following:

1) Zone maximum discharge air temperature above heating setpoint (MaxΔT) = 25°F

2) The heating minimum airflow setpoint (Vheat-min) = 0

B. Control logic is depicted schematically in figure below and described in the following sections. Relative levels of various setpoints are depicted for Occupied Mode operation.

a) When the zone is in the Heating Mode, the Heating Loop shall be mapped as follows:

1. From 0-100%, the Heating Loop output shall reset the discharge temperature from 95°F to 115°F.

b) The hot water valve shall be modulated using P+I loop to maintain the discharge temperature at setpoint. (Directly controlling HW valve off zone temperature PID loop is not acceptable.)

C. Alarms

1. Low discharge air temperature

   a. If heating hot water plant is proven on and the discharge air temperature is 8°C (15°F) less than setpoint for 10 minutes, generate a Level 3 alarm.
b. If heating hot water plant is proven on and the discharge air temperature is 17°C (30°F) less than setpoint for 10 minutes, generate a Level 2 alarm.

c. If a zone has an Importance-Multiplier of 0 for its Hot Water reset Trim &Respond control loop, low discharge air temperature alarms shall be suppressed for that zone.

3.3 Leaking valve. If the valve position is 0% for 15 minutes, discharge air temperature is above AHU SAT by 3°C (5°F), and the fan serving the zone is proven on, generate a Level 4 alarm.

Hydronic Load Monitoring

A. Trend the BTU meter for total HHW and CHW entering the building at 15min intervals.

B. Totalize the BTU for HHW and CHW consumed for each 24-hour day.

C. Trend the OSA temp for every day at 15min intervals.

D. Trend the OSA temp high every day.

E. Pass the differential pressure setpoint back to the central plant every 5 minutes.

F. Pass the total hydronic load for the HHW and CHW of the building back to the central plant every 5 minutes.

G. Note: coordinate with central plant sequence of operation as part of the Art Building project which is outside the scope of this project.

3.4 Advanced Energy Metering

A. Design intent is to capture and organize the resource data from the meters on the contract documents such that:

1. The categories below can appear as a real time graph based on 15min intervals

2. All intervals are stored for 24 months

3. All intervals are auto-exported monthly and annually in .csv

4. The categories below can be exported on command into .csv for further analysis by a 3rd party engineer.

5. Note: the design intent is not to capture the full suite of energy reporting functions possible by the BMS front end. Key performance indicators do not apply, fault detection does not apply, separate software as a service does not apply. Just use the functions available to the existing campus front end to display and export aggregated resource data.

B. All of the source meters indicated in the control diagrams on the mechanical drawings need to be trended, tabulated and displayed on the ALC front end in the following way

1. All meters/resources shall be aggregated as indicated on the drawings. Any summations, subtractions or conversion factors to achieve such aggregation is the responsibility of the DDC programmer.

   a. Example: if lighting load is the sum of multiple meters, present lighting as a single aggregated value not just 3 separate lighting meters that the owner would have to manually sum.
b. Example: plug load is a “virtual meter” obtained by subtracting other loads from the total bldg. consumption.

2. Create a tab for each resource type: electrical, water, thermal

3. Within these 3 tabs, sub divide the resource into separate components as follows:
   a. Electrical loads to be separated as lighting, HVAC and plug. Each of these categories to contain kW, kWh, and power factor.
   b. Water consumption to be separated as cold-water consumption, hot water energy, irrigation.
   c. Thermal energy to be separated as aggregated HVAC power, central plant hydronic energy consumed by bldg.

4. Each sub category of a given resource to be trended with the sub category on the y-axis and time on the x-axis. Use 15 min intervals on x-axis showing a 24-hour window.

5. Every meter must be totalized daily and those daily totals stored as separate records. Display daily records in tabular format of 30 days. Also display in graphical format with a sub category of a given resource on the y-axis and time on the x-axis. Use intervals of 1 day on the x-axis showing a 30-day window.

6. All graphs are to be live data, not historical snapshot.

7. Show present value of all sub categories for a given resource as its own section of the tab independent of all graphs.

8. All trends must be auto-exported to owner specified email recipient in .csv file monthly. Monthly trends should only contain the trends for that month.

9. All trends must auto-export of all energy trends should be emailed annually. This data to contain data for the entire year.

10. Store all trends for 24 months at the front end not at any controllers. Provide any front-end software license necessary to achieve this timescale and/or records keeping.

11. Provide 20” LCD screen on articulating wall arm mount for the purpose of displaying real time resource screens.
   a. Single screen for all 3 PE-K bldgs., not one per bldg
   b. Owner to indicate location, suggest lobby
   c. Power to be from existing 120V power source.
   d. LCD is to be touch screen, no mouse. Comply with ADA height requirements. Free standing display is not required. Table stand for lobby table is acceptable with written permission from owner.
   e. DDC contractor responsible for requesting and obtaining permission from owner and architect for wall mount bracket, location and plug source
   f. Provide windows media server in DDC cabinet OR smart TV with wifi so that no windows media server is necessary.
g. Coordinate with owner IT dept to provide VPN connection to the campus front end.

h. DDC contractor to provide lowest level user profile with zero control permissions and view only access to the energy tabs of the front end. Use this login for the kiosk screen so that once logged in, a user could touch the screen to toggle through the three resource tables.

i. Screen only needs to display the energy tabs created in this spec section. Outwardly facing screens are outside the scope of this project. Design intent is to provide awareness and make ready the way for future in-house development on the part of the owner.

12. Alarming
   a. Any comm failure or loss of data to be alarmed at the front end and sent as an email.

   b. Data with erroneous values must produce an alarm. Example: 999.99 kwh would indicate maxed variable scale and/or is impossible.
B. AHU Single Zone – OEM Controls

1. General
   a. This sequence provides a general outline for the correct selection of OEM controls from the equipment manufacturer. OEM control functions may vary slightly in their execution. All controls to be pre-wired at the factory and provided with a BACnet MS/TP gateway.
   b. BMS is to integrate to the OEM controls to provide graphic representation of the equipment at the front end, annunciate all alarms, and to control the unit through setpoints.

2. Supply Fan and Air Temperature Control
   a. Supply air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the hot water valve and/or chilled water valve as shown in the diagram below.

![Diagram showing discharge air temperature control](image-url)
b. Figure above: there are two axes on the graph above. The line style of the axis corresponds to the associated line on the graph. The dashed line corresponds to the AHU DAT. The solid lines correspond to the AHU cfm.

c. The design airflow setpoints for each zone shall be scheduled on the drawings for cooling max, heating max, and design min cfm. TAB support to determine what speeds provide the appropriate cfm may be required if any kind of AFMS or flow ring is not shown on the controls diagrams.

d. The HHW and CHW valve(s) shall be modulated with a PI loop to maintain the discharge temperature at setpoint across the range of air flow.

e. When the zone is in cooling, the cooling loop shall reset the active air flow setpoint from the min air flow setpoint to the max cooling airflow setpoint.

f. When the zone is in heating, the heating loop shall reset the active air flow setpoint from the min air flow setpoint to the max heating airflow setpoint.

g. When the zone in deadband, the active airflow setpoint shall be the min airflow setpoint and all coil valves shall be closed.

3. Economizer Control

a. Design intent is for OA and RA economizer dampers to modulate to allow for free cooling when conditions are favorable AND to maintain minimum outdoor air.

b. The min OA control loop output is always to take priority over the free cooling loop.

c. The OA cfm feedback is measured by the OA AFMS, not based on a TAB setpoint.

d. When conditions are favorable for free cooling, the economizer shall modulate to maintain the mixed air averaging temp sensor (dry bulb only) at SAT setpoint minus 2°F (adj) but not at the expense of min OA.

e. Mixed air temp setpoint initially set equal to DAT setpoint minus 2°F (adj).

f. Favorable conditions are defined as:

1) OAT ≤75°F
2) OAT < RAT
3) OAT > 40°F (adj)

g. Outside Air Damper Lockout: If the outside air temperature is greater than the return air temperature, then modulate dampers to the minimum position.

4. Economizer – Other Modes

a. Morning warmup mode or cool down mode (as applicable)

1) This is schedule based and is set by the building owner.

2) The building is assumed to be completely unpopulated which allows for 100% RA and 0% OA.
3) To expedite the warmup of the building (example: after a cold night), the OA dampers shall be fully closed for 100% recirculation so long as OAT < RAT

4) To expedite the cool down of the building (example: after a hot weekend), the OA dampers shall be fully closed for 100% recirculation so long as OAT > RAT

5. Alarms
   a. Generate a maintenance alarm when fan has operated for more than 1500 hours or as recommended by the product manufacturer. Reset interval counter when alarm is acknowledged.
   b. High space temperature: if thermostat rises more than 5°F above setpoint for 10 minutes, send alarm.
   c. If supply fan fails to reach commanded state for more than 5 min, send alarm.
   d. Generate a maintenance alarm when the filter DP has exceeded threshold of .2’ w.c. (adj).

6. System Requests
   a. Not applicable

7. Testing Commissioning Overrides:
   a. Allow for all inputs and outputs to be manually manipulated to aide in commissioning.

8. Trends
   a. The following trends should be made on 15min intervals and auto-exported to an admin user in .csv or .xml format:
      1) SAT and setpoint
      2) HHW & CHW valve position
      3) RAT, OAT
      4) OA CFM (as applicable, see controls diagrams)
      5) Supply Fan CFM, DP, DP setpoint (as applicable, see controls diagrams)
      6) Space thermostat temp & setpoint

C. AHU Multiple Zone– OEM Controls

1. General
   a. This sequence provides a general outline for the correct selection of OEM controls from the equipment manufacturer. OEM control functions may vary slightly in their execution. All controls to be pre-wired at the factory and provided with a BACnet MS/TP gateway.
   b. BMS is to integrate to the OEM controls to provide graphic representation of the equipment at the front end, annunciate all alarms, and to control the unit through setpoints.
c. This is a standard VAV AHU that provides cooling air to VAV with reheat.

2. Modes
   a. In unoccupied mode the AHU is to remain off, with any coil valves closed and any OA or EA dampers closed.
   b. For morning warm-up, AHU will run with a supply air temp of 90°F (adj).
   c. In morning warm-up or cool-down, the AHU logic is the same as occupied mode with the exception being that OA & EA dampers may remain fully closed for 100% recirculation if conditions for heating/cooling are not favorable.
   d. All other logic in this sequence pertains to occupied mode.

3. Supply Fan Control
   a. The supply fan will modulate with PI control to maintain a remote duct pressure setpoint.
   b. All fans control in unison to single output signal. (as applicable)
   c. Totalize current airflow rate from VAV boxes and display on AHU graphic.
   d. Display the AHU AFMS airflow rate adjacent to the sum-of-zone airflow rate. (as applicable)
   e. Note: high static switch is to be directly connected to emergency shut down input on supply fan(s) rather than rely on DDC logic.

4. Static Pressure Setpoint Reset
   a. DDC system shall pass the static pressure setpoint to the AHU through integration.
   b. Design intent is for this pressure setpoint to gradually lower itself and be reset higher by requests from terminal units using trim and respond logic.
   c. Example: the supply fan pressure setpoint will gradually lower itself in .1” w.c. (adj) increments about every 10 min (adj) unit dampers downstream start approaching maximum open position. At this point they will generate requests for more pressure and the AHU will need to then respond by lifting the pressure back up.
   d. See terminal unit sequences for complete specifics how fan pressure requests are generated.
   e. Suggested initial parameters for trim and respond are tabulated below. DDC Contractor responsible for tuning to provide stable operation. Seasonal tuning, if not explicitly stated elsewhere in the contract documents is outside the scope of this project.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Supply Fan</td>
</tr>
<tr>
<td>SP₀</td>
<td>0.5 inches</td>
</tr>
<tr>
<td>SPₘᵢₙ</td>
<td>0.1 inches</td>
</tr>
<tr>
<td>Variable</td>
<td>Value</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>$SP_{\text{max}}$</td>
<td>3 inches</td>
</tr>
<tr>
<td>$T_d$</td>
<td>10 minutes</td>
</tr>
<tr>
<td>$T$</td>
<td>2 minutes</td>
</tr>
<tr>
<td>$I$</td>
<td>2</td>
</tr>
<tr>
<td>$R$</td>
<td>Duct Static Pressure Reset Requests</td>
</tr>
<tr>
<td>$SP_{\text{trim}}$</td>
<td>-0.05 inches</td>
</tr>
<tr>
<td>$SP_{\text{res}}$</td>
<td>+0.06 inches</td>
</tr>
<tr>
<td>$SP_{\text{res-max}}$</td>
<td>+0.18 inches</td>
</tr>
</tbody>
</table>
5. Supply Air Temperature Control  
   a. Use a PI loop to modulate the control valve to maintain discharge air temp at heating/cooling setpoint across the range of supply cfm. Controls contractor to provide tuning for stable operation.

6. Economizer Control  
   a. Design intent is for OA and RA economizer dampers to modulate to allow for free cooling when conditions are favorable AND to maintain minimum outdoor air.
   b. BMS to calculate the min OA required for each VAV zone in real time to capture the changes in flow resulting from demand control ventilation. These values are to be summed and passed to the AHU controller upon change of value.
   c. The min OA control loop output is always to take priority over the free cooling loop.
   d. The OA cfm feedback is measured by the OA AFMS, not based on a TAB setpoint.
   e. When conditions are favorable for free cooling, the economizer shall modulate to maintain the mixed air averaging temp sensor (dry bulb only) at SAT setpoint minus 2°F (adj) but not at the expense of min OA.
   f. Mixed air temp setpoint initially set equal to DAT setpoint minus 2°F (adj).
   g. Favorable conditions are defined as:
      1) OAT ≤75°F
      2) OAT < RAT
      3) OAT > 40°F (adj)
   h. Outside Air Damper Lockout: If the outside air temperature is greater than the return air temperature, then modulate dampers to the minimum position.

7. Economizer – Other Modes  
   a. Morning warmup mode or cool down mode (as applicable)
      1) This is schedule based and is set by the building owner.
      2) The building is assumed to be completely unpopulated which allows for 100% RA and 0% OA.
      3) To expedite the warmup of the building (example: after a cold night), the OA dampers shall be fully closed for 100% recirculation so long as OAT < RAT
      4) To expedite the cool down of the building (example: after a hot weekend), the OA dampers shall be fully closed for 100% recirculation so long as OAT > RAT
   b. Night flush mode
      1) This mode assumes night time OAT is suitable for cooling for approx. 2-4 hours.
2) The schedule for this mode should be compared against OAT to be sure favorable conditions are present. Schedule based is set by the building owner.

3) The building is assumed to be completely unpopulated.

4) Command all associated terminal units to a thermostat setpoint of 60°F (adj). Without running the CHW plant, use 100% OA supply from the AHU to cool the zones. Same supply fan and return control logic from occupancy mode to be used.

8. Plant Requests
   1) Not applicable.

9. Alarms
   a. Maintenance
      1) Interval alarm when fan has operated for more than 1,500 hours: Level 5. Reset interval counter when alarm is acknowledged.
      2) Annunciate any alarms available through integrations to heat wheel or fan wall OEM packages.
      3) Generate a maintenance alarm when the filter DP has exceeded threshold of .2 w.c. (adj).
   b. Fans
      1) If the VFD is shut down by a high/low static switch, annunciate at the highest level alarm.
      2) If fan status or feedback does not match commanded setpoint for a period of 60 seconds, send alarm
      3) If building pressure is greater than .10", send alarm.
      4) If building pressure is less than .00" (negative), send alarm.
   c. Filter
      1) If pressure drop exceeds alarm limit, send alarm.
   d. Supply Air Temperature
      1) If supply air temperature exceeds 100°F or drops below 40°F, send alarm

10. Testing Commissioning Overrides:
   a. Allow for all inputs and outputs to be manually manipulated to aide in commissioning.

11. Trends
   a. The following trends should be made on 15min intervals and auto-exported to an admin user in .csv or .xml format:
      1) SAT and setpoint
      2) HHW & CHW valve position
3. Radiant Manifold

A. Radiant manifold serve one or more space temperature sensors if the radiant zone overlaps with several VAV zones. See Drawings. If more than one:

1. The control heating loop output shall be the highest heating loop output from the radiant zones served by the manifold.

2. The control cooling loop output shall be the highest cooling loop output from the radiant zones served by the manifold.

B. Slab Temperature Setpoints

1. Maximum Slab Temperature Setpoint, \( STSP_{\text{max}} \), shall equal 85°F (adj.).

2. Minimum Slab Temperature Setpoint, \( STSP_{\text{min}} \), shall equal the greater of 65°F (adj.) and 1°F (adj.) more than the present outdoor air dew point temperature.

3. Neutral Temperature Setpoint, \( STSP_{\text{neut}} \), shall equal the average of the active radiant zone heating and cooling setpoints for the zone served by the manifold.

C. Slab Temperature Setpoint Reset

1. Upper and lower limits of the reset range shall be \( STSP_{\text{max}} \) and \( STSP_{\text{min}} \).

2. When the Radiant Water Loop serving the manifold is indexed to Heating Mode, Slab Temperature Setpoint shall be reset from \( STSP_{\text{min}} \) at 0% control heating loop output to \( STSP_{\text{max}} \) at 100% control heating loop output.

3. When the Radiant Water Loop serving the manifold is indexed to Cooling Mode, Slab Temperature Setpoint shall be reset from \( STSP_{\text{max}} \) at 0% control cooling loop output to \( STSP_{\text{min}} \) at 100% control cooling loop output.

D. Slab Temperature Control

1. When in heating mode, the 2-position manifold valve shall open when slab temperature falls 1°F below setpoint and close when slab temperature exceeds setpoint.

2. When in cooling mode, the 2-position manifold valve shall open when the slab temperature is 1°F above setpoint and close when slab temperature falls below setpoint.

3. Valve Lockout: When valve lockout logic is triggered, it shall override all preceding valve control logic.
a. When in heating mode and all radiant zones served by the manifold are above zone heating setpoint for 5 minutes continuously, manifold valve shall be closed. Valve shall remain locked out until any radiant zone served by the manifold falls below its heating setpoint.

b. When in cooling mode and all radiant zones served by the manifold are below cooling setpoint for 5 minutes continuously, manifold valve shall be closed. Valve shall remain locked out until any radiant zone served by the manifold rises above its cooling setpoint.

c. When the radiant loop changes modes, the manifold valve shall not be allowed to open until it has been closed for at least 3 hours (e.g. if the manifold valve were last open in heating mode 120 minutes prior to the loop switching to cooling mode, the valve would remain shut for another 60 minutes before being unlocked for cooling control).

E. Alarms
1. Slab temperature drops to 62°F for 15 minutes (adj.) continuously. Level 2.
2. Slab temperature rises above 90°F for 15 minutes (adj.) continuously. Level 2.

F. Radiant Water Loop Requests
1. If the manifold control valve is open for 1 minute continuously, send 1 request.
2. If the manifold control valve is closed, send 0 requests.

3.6 Exhaust Fans
A. Exhaust fans shall operate when any of the associated system supply fans is proven on and any associated Zone Group is in the occupied mode.

B. Speed to be set by the TAB Contractor such that when min DCV air is being supplied by all zones with space CO2 sensors, exhaust fans maintain building at .1” static positive.

C. Note: as the DCV zones ramp up the full ventilation air, the gravity relief damper will provide necessary additional relief air.

D. Alarms
1. Generate a Level 4 maintenance alarm when fan has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
   a. Commanded on, status off: Level 2
   b. Commanded off, status on: Level 4

3.7 Laundry Room VAV with Economizer
A. The three laundry machines shall each have a CT to detect if they are running.
B. DDC contractor to step in VAV cfm inputs that correspond with the number of laundry machines running.

C. Outdoor air damper shall control to provide the min OA percentage for the active cfm setpoint.

3.8 Ceiling Fans
A. These are manually operated by users at the OEM wall switch.
B. BMS to switch them off at night with BO contact.

3.9 Fan Coils – OEM Controls
A. This sequence provides a general outline for the correct selection of OEM controls from the equipment manufacturer. OEM control functions may vary slightly in their execution
B. Fan control
   1. During the Cooling mode
      a. The fan shall run when zone is in Cooling Mode. It shall be off otherwise.

C. Supply Air Temperature Control
   1. Control loop is enabled when the supply air fan is proven on, and disabled and output set to zero otherwise.

D. Alarms
   1. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.
   2. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
      a. Commanded on, status off: Level 2
      b. Commanded off, status on: Level 4

3.10 System Commissioning
A. Sequencing. The following list outlines the general sequence of events for submittals and commissioning:
   1. Submit Submittal Package 0 (Qualifications) and receive approval.
   2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
   3. Initiate installation of BAS hardware, devices and wiring.
   4. Develop point database and application software.
   5. Simulate sequencing and debug programming off-line to the extent practical.
   6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
   7. Complete installation of BAS hardware, devices and wiring.
   8. Install point database and application software in field panels.
   9. Submit Submittal Package 3 (Functional Testing) and receive approval.
10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit completed Pre-functional Test Forms for approval.

11. Field test application programs prior to functional testing.


13. Prepare and initiate commissioning Trend Logs.

   a. Some tests may not be possible due to weather conditions. These tests may be deferred to post-occupancy period.

15. Assist in TAB tests and determining setpoints as specified in Section 230593 Testing, Adjusting and Balancing.


17. Submit Package 4 (Training Materials) and receive approval.

18. Receive BAS Functional Test Report approval and approval to schedule Demonstration Tests.


21. Train Owner personnel on BAS operation and maintenance.

22. Substantial Completion

23. Submit Package 5 (Post-Construction Trend Logs) in format specified for review and approval.

24. Receive approval of successful Trend Log tests, or retest as required.

25. Complete all items in Completion Requirements

26. Provide administration level password access to the Owner.

27. Final Acceptance


29. Prepare and initiate post-occupancy Trend Logs.

30. Update all software as specified.

31. End of Warranty Period

B. Test Documentation

1. Pre-functional Tests
   a. Prepare forms to document the proper startup of the BAS components.
   b. All equipment shall be included on test forms including but not limited to
1) Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.

2) Digital Outputs: Proper installation, normal position, response to command at CU

3) Digital Inputs: Proper installation, device test, response at CU

4) Analog Outputs: Proper installation of devices, verification of maximum and minimum stroke.

5) Analog Inputs: Proper installation of sensors, calibration

6) Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.

7) Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.

8) Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.


c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

d. Submit forms for approval in Submittal Package 3.

e. Complete work, document results on forms, and submit for approval as Pre-Functional Test Report.

2. Functional Tests

a. Owner’s Representatives will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.

b. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc.

c. Adapt forms from Owner’s Representative into electronic format. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

d. Submit forms for approval in Submittal Package 3.

e. Complete work, document results on forms, and submit for approval as Functional Test Report.

C. Assist Commissioning Provider/Coordinator as specified in Section 019100 Commissioning, including attending commissioning meetings.

D. Coordinate with Work specified in Section 230800 Mechanical Commissioning and Division 26 Electrical Commissioning.
E. Pre-functional tests

1. General
   a. Inspect the installation of all devices. Review the manufacturer’s installation instructions and validate that the device is installed in accordance with them.
   b. Verify proper electrical voltages and amperages and verify that all circuits are free from faults.
   c. Verify integrity/safety of all electrical connections.
   d. Verify that shielded cables are grounded only at one end.
   e. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.

2. Digital Outputs
   a. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

3. Digital Inputs
   a. Adjust setpoints, where applicable.
      1) For current switches used as status on fans, adjust current setpoint so that fan status is OFF when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
      2) For current switches used as status on pumps, adjust current setpoint so that pump status is OFF when pump is dead-headed (temporarily close discharge valve).
      3) For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).

4. Analog Outputs
   a. Verify start and span are correct and control action is correct.
   b. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
   c. Check all normal positions of fail-safe actuators.
   d. For outputs to reset other manufacturer's devices (for example, ASHP setpoint) and for feedback from them, calibrate ranges to establish proper parameters.

5. Analog Input Calibration
   a. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
      1) Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
      2) Handheld: Field calibrate using a handheld device
b. The calibrating parameters in software (such as slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.

c. Inaccurate sensors must be replaced if calibration is not possible.

6. Alarms and Interlocks

a. A log shall be kept and initialed by the technician indicating date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.

b. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

c. Coordinate with Division 26 to test fire and life safety systems alarm contacts.

d. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

e. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

7. Variable Frequency Drive Minimum Speed

a. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor losses to be minimal at low speeds.

b. This work shall be done only after fan/pump system is fully installed and operational.

c. Determine minimum speed setpoint as follows:
   1) Start the fan or pump.
   2) Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
   3) Observe fan/pump in field to ensure it is visibly rotating.
      a) If not, gradually increase speed until it is.
   4) The speed at this point shall be the minimum speed setpoint for this piece of equipment.
   5) Record minimum speeds in log and store in software point as indicated in Guideline 36.

8. Tuning

a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for
each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted).

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct Pressure</td>
<td>±0.1 inches w.g.</td>
</tr>
<tr>
<td>Building and relief plenum</td>
<td>±0.01 inches w.g.</td>
</tr>
<tr>
<td>Airflow and water flow</td>
<td>±10%</td>
</tr>
<tr>
<td>Space Temperature</td>
<td>±1.5°F</td>
</tr>
<tr>
<td>Condenser Water Temperature</td>
<td>±2°F</td>
</tr>
<tr>
<td>Chilled Water Temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±3°F</td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>±2°F</td>
</tr>
<tr>
<td>Water Differential Pressure</td>
<td>±1.5 psi</td>
</tr>
<tr>
<td>Others</td>
<td>±2 times reported accuracy</td>
</tr>
</tbody>
</table>

9. Interface and Control Panels
   a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
   b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
   c. Check power supplies for proper voltage ranges and loading.
   d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
   e. Check for adequate signal strength on communication networks.
   f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
   g. Ensure that buffered or volatile information is held through power outage.
   h. With all system and communications operating normally, sample and record update and annunciation times for critical alarms fed from the panel to the Operator Interface.
   i. Check for adequate grounding of all BAS panels and devices.
10. Operator Interfaces
   a. Verify that all elements on the graphics are functional and are properly bound to physical devices or virtual points, and that hot links or page jumps are functional and logical.
   b. Verify that the alarm logging, paging, emailing etc. are functional and per requirements.

F. Testing, Adjusting, and Balancing (TAB) Coordination
   1. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing. Some balancing procedures require the BAS to be operational and require Contractor time and assistance.

   2. Calibration Software
      a. Software shall be provided free of charge on at least a temporary basis to allow calibration of terminal box airflow controls and other Work specified under Section 230593 Testing, Adjusting, and Balancing.
      b. Software shall be provided for installation on POT(s) provided by Others or Contractor shall loan a POT or handheld device with software installed for the duration of Work specified under Section 230593 Testing, Adjusting, and Balancing.
      c. Provide sufficient training to those performing Work specified under Section 230593 Testing, Adjusting, and Balancing to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session for this purpose.

   3. Setpoint Determination
      a. Perform pre-functional tests before assisting in setpoint determination.
      b. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to determine fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 230593 Testing, Adjusting and Balancing.

G. Functional Tests
   1. Test schedule shall be coordinated with the Commissioning Provider, Commissioning Coordinator, and Owner’s Representative.
   2. Functional tests may be witnessed by Owner’s Representative at the Owner’s option.
   3. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor’s start-up technician.
   4. Test documentation shall be submitted to the Owner for review and approval.

H. Demonstration Test
   1. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Commissioning Provider. Tests will be designed to occur over no longer than 2 working days.
2. Schedule the demonstration with the Commissioning Provider and Owner’s Representative at least 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.

3. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

4. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Provider will supply the test forms at the site at the start of the tests.

5. Demonstration tests may be witnessed by Owner’s Representative at the Owner’s option.

6. Contractor shall conduct tests as directed by and in the presence of the Commissioning Provider and complete test forms. Completed forms shall be submitted as the Demonstration Test Report to the Commissioning Provider after tests are complete.

7. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

I. Trend Log Tests

1. Trends shall be fully configured to record and store data to the server for the points and at the interval
   a. Commissioning: Configure trends prior to functional testing phase. Retain configuration until post-construction commissioning trend review has been completed successfully and accepted by the Owner’s representative.

J. Remedial Work

1. Repair or replace defective Work, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

2. Restore or replace damaged Work due to tests as directed by Owner’s Representative in writing, at no additional cost to the Owner.

3. Restore or replace damaged Work of others, due to tests, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Owner’s Representative, at no additional cost to the Owner.

5. Contractor shall compensate Owner’s Representatives and Commissioning Provider on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the Owner.

3.11 Training

A. Coordinate schedule and materials with Commissioning Authority.
B. Formal Training
   1. Training shall be conducted after all commissioning is complete and systems are fully operational.
   2. ALC Training
      a. It may be assumed that College building engineers have been previously trained on the existing ALC system.
      b. Include training on ALC system operations only for new features installed at CSS/OWS as a part of this project.
   3. Jobsite Training
      a. Include 24 hours total of on-site training to assist personnel in becoming familiar with job-specific issues, systems, control sequences, etc.
      b. College shall be permitted to videotape training sessions.
   4. Training may be in non-contiguous days at the request of the College.

3.12 Advanced metering responsibility matrix

<table>
<thead>
<tr>
<th>Scope Category</th>
<th>Scope Item</th>
<th>Div 22</th>
<th>Div 23</th>
<th>Div 25</th>
<th>Div 26</th>
<th>Owner IT</th>
<th>Civil Reclaimed Underground Utilities Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BIM and path/location coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>provide for scope</td>
</tr>
<tr>
<td></td>
<td>trenching</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>provide in full</td>
</tr>
<tr>
<td></td>
<td>underground pipe</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>provide in full</td>
</tr>
<tr>
<td></td>
<td>BIM and path/location coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>provide for scope</td>
</tr>
<tr>
<td></td>
<td>purchase correct meter for use case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>select meter body, type, connection for Div 23</td>
</tr>
<tr>
<td></td>
<td>physically install meter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>select meter body, type, connection for Div 23</td>
</tr>
<tr>
<td></td>
<td>verify proper installation and good data is coming from meter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lead, ultimately responsible for correct installation</td>
</tr>
<tr>
<td></td>
<td>underground conduit and wire from meter into building</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>provide</td>
</tr>
</tbody>
</table>

Site Meters & Alarm Devices OUTSIDE THE BUILDING including but not limited to: Domestic Water, Irrigation, Remote Photovoltaics, CHW/HHW Hydronics
### B. Metering Within the Building

<table>
<thead>
<tr>
<th>Scope Category</th>
<th>Scope Item</th>
<th>Div 22</th>
<th>Div 23</th>
<th>Div 25</th>
<th>Div 26</th>
<th>Owner IT</th>
</tr>
</thead>
<tbody>
<tr>
<td>underground wire terminations inside building, power up, point-to-point checkout to verify correct installation</td>
<td>assist</td>
<td>-</td>
<td>lead</td>
<td>assist</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>24V &amp;/or signal wire and conduit from underground wire entry into bldg to BMS panel in IDF/Elec/Mech Room</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>120V power to BMS panel</td>
<td>-</td>
<td>-</td>
<td>provide locations necessary to Div 26</td>
<td>provide 120V power to metering panel mounted by Div 25</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>metering network architecture design to meet project docs</td>
<td>-</td>
<td>-</td>
<td>provide network submittal</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>controllers, enclosure, serial &amp; ethernet devices, and all accessories for a complete assembly</td>
<td>-</td>
<td>-</td>
<td>provide in full</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>serial/ethernet network connectivity verification</td>
<td>-</td>
<td>-</td>
<td>responsible for all network engineering and programming</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>establish connectivity to enterprise server</td>
<td>-</td>
<td>-</td>
<td>lead</td>
<td>-</td>
<td>assist</td>
<td>-</td>
</tr>
<tr>
<td>meter programming; all digital work to pull meter data into existing enterprise software</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>virtual meters programming, all calculations necessary to create virtual meters as specified</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>data aggregation, combining meter data sets as specified to meet target certifications</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>trending at specified intervals</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>automated transmission of specified trends to the appropriate parties for M&amp;V and target certifications</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BIM and path/location coordination</td>
<td>locate meter in BIM with LOD per project docs</td>
<td>locate meter in BIM with LOD per project docs</td>
<td>metering panel locations and conduit as needed per project docs</td>
<td>locate meter in BIM with LOD per project docs</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>purchase correct meter for use case</td>
<td>select meter body, type, connection</td>
<td>-</td>
<td>select meter body, type, connection for Div 23</td>
<td>select meters for all electric applications, including integrated power data (lighting, PV, etc.)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>physically install meter</td>
<td>provide</td>
<td>provide</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>verify proper installation and good data is coming from meter</td>
<td>lead, ultimately responsible for correct installation</td>
<td>lead, ultimately responsible for correct installation</td>
<td>assist</td>
<td>lead, ultimately responsible for correct installation</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>24V &amp;/or signal wire and conduit from meters to bms panel in IDF/Elec/Mech Room</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>provide</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>120V power to bms panel</td>
<td>-</td>
<td>-</td>
<td>provide network submittal</td>
<td>provide 120V power to metering panel mounted by Div 25</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>metering network architecture design</td>
<td>-</td>
<td>-</td>
<td>provide network submittal</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>controllers, enclosure, all panel accessories for complete assembly</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>ethernet/fiber/conduit connections among bms panels</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>metering serial/ethernet network connectivity verification</td>
<td>-</td>
<td>-</td>
<td>responsible for all network engineering and programming</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>establish connectivity to enterprise server</td>
<td>-</td>
<td>-</td>
<td>lead</td>
<td>-</td>
<td>assist</td>
<td></td>
</tr>
<tr>
<td>meter programming: all digital work to pull meter data into existing enterprise software</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>virtual meters programming, all calculations necessary to create virtual meters as specified</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>data aggregation, combining meter data sets as specified to meet target certifications</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Meters & Alarm devices WITHIN THE BUILDING including but not limited to: domestic water, electric sub meters of every kind, lighting energy use, plug Load.
<table>
<thead>
<tr>
<th>trending at specified intervals</th>
<th>-</th>
<th>-</th>
<th>provide</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>automated transmission of specified trends to the appropriate parties for M&amp;V and target certifications</td>
<td>-</td>
<td>-</td>
<td>provide</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

END OF SECTION 250000
SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.03 DEFINITIONS

A. Jacket: A continuous nonmetallic outer covering for conductors or cables.
C. Sheath: A continuous metallic covering for conductors or cables.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.
B. Samples: 16-inch lengths for each type of cable specified.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Indicate location of each cable, splice, and termination.
B. Qualification Data: For Installer.
C. Material Certificates: For each type of cable and accessory.
D. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.
E. Source quality-control reports.
F. Field quality-control reports.
1.06 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: Member Company of NETA or an NRTL.
   1. Testing Agency’s Field Supervisor: Certified by NETA to supervise on-site testing.

1.07 FIELD CONDITIONS

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than five days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without Owner’s written permission.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.02 CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aetna Insulated Wire, Inc.
   2. Kerite Co. (The).
   3. Okonite Company (The).

B. Cable Type: Type MV 105.

C. Conductor Insulation: Ethylene-propylene rubber.
   1. Voltage Rating: 15 kV.
   2. Insulation Thickness: 133 percent insulation level.

D. Conductor: Copper.
E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.

F. Conductor Stranding: Compact round, concentric lay, Class B.

G. Shielding: Copper tape, helically applied over semiconducting insulation shield. Minimum of 25% overlap.

H. Cable Jacket: Sunlight-resistant PVC.

2.03 CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.

B. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

2.04 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. 3M.
3. Raychem; TE Connectivity.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Dead-Break Cable Terminators: Elbow-type unit with [200] [600]-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer’s standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders and carrying case.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.05 MEDIUM-VOLTAGE TAPES
A. Description: Electrical grade, insulating tape rated for medium voltage application.
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   3. Raychem; TE Connectivity.
C. Ethylene/propylene rubber-based, 30-mil splicing tape, rated for 130 deg C operation. Minimum 3/4 inch wide.
D. Silicone rubber-based, 12-mil self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

2.06 ARC-PROOFING MATERIALS
A. Description: Fire retardant, providing arc flash protection.
B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M.
   3. Raychem; TE Connectivity.
C. Tape for First Course on Metal Objects: 10-mil-thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
D. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3-inch-thick, and compatible with cable jacket.
E. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch wide.
2.07 FAULT INDICATORS

A. Indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

2.08 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.

2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.

4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Support cables according to Section 26 05 29 “Hangers and Supports for Electrical Systems.”

E. Install “buried-cable” warning tape 12 inches above cables.

F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.
G. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

I. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
   2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
   3. Standoff Insulator: At each terminal junction, with one on each terminal.

J. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer’s written instructions, apply arc proofing as follows:
   1. Clean cable sheath.
   2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
   3. Smooth surface contours with electrical insulation putty.
   4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
   5. Band arc-proofing tape with two layers of 1-inch-wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

K. Seal around cables passing through fire-rated elements according to Section 07 84 13 “Penetration Firestopping.”

L. Install fault indicators on each phase where indicated.

M. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

N. Identify cables according to Section 26 05 53 “Identification for Electrical Systems.” Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.02 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
   3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer’s recommended maximum test voltage.
4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer’s recommendations.
5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer’s recommendations.

C. Medium-voltage cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION
SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
   1. Copper building wire rated 600 V or less.
   2. Metal-clad cable, Type MC, rated 600 V or less.
   3. Armored cable, Type AC, rated 600 V or less.
   4. Connectors, splices, and terminations rated 600 V and less.
   5. Electrical Power Aerial Cable rated 600V or less.

1.03 DEFINITIONS
A. RoHS: Restriction of Hazardous Substances.
B. VFC: Variable-frequency controller.

1.04 ACTION SUBMITTALS
A. Sustainable Design Submittals:
   1. Product Data: For each conductor and cable indicating lead content.
   2. Product Data: For recycled content, indicating postconsumer and pre-consumer recycled content and cost.
   3. Product Data: For solvents and adhesives, indicating VOC content.
   4. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.
B. Shop Drawing: A single submittal is required for all products covered by this Section.

1.05 INFORMATIONAL SUBMITTALS
A. Qualification Data: For testing agency.
B. Field quality-control reports.

1.06 QUALITY ASSURANCE
A. Testing Agency Qualifications: Member company of NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
PART 2 - PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Alpha Wire Company.
   2. American Bare Conductor.
   3. Belden Inc.
   4. Cerro Wire LLC.
   5. Encore Wire Corporation.
   6. General Cable Technologies Corporation.
   7. Okonite Company.
   8. Service Wire Co.
  10. WESCO.
  11. Or approved equal

C. Standards:
   1. Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Conductor Insulation:
   1. Type NM: Comply with UL 83 and UL 719.
   2. Type RHH and Type RHW-2: Comply with UL 44.
   3. Type USE-2 and Type SE: Comply with UL 854.
   4. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
   5. Type THHN and Type THWN-2: Comply with UL 83.
   6. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
   7. Type UF: Comply with UL 83 and UL 493.
   8. Type XHHW-2: Comply with UL 44.

2.02 ARMORED CABLE, TYPE AC

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Alpha Wire Company.
2. American Bare Conductor.
3. Belden Inc.
4. Cerro Wire LLC.
5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Okonite Company (The).
8. Service Wire Co.
10. WESCO.
11. Or approved equal.

C. Standards:
   1. Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.
   2. RoHS compliant.
   4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:

E. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation: Type THHN/THWN-2. Comply with UL 83.

H. Armor: Steel, interlocked.

2.03 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. 3M Electrical Products.
   2. AFC Cable Systems; a part of Atkore International.
   5. Ideal Industries, Inc.
   6. ILSCO.
   7. NSi Industries LLC.
   8. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. TE Connectivity Ltd.
11. Thomas & Betts Corporation; A Member of the ABB Group.
12. Or approved equal.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper.
   2. Type: Two hole with long barrels.
   3. Termination: Crimp.

2.04 ELECTRICAL POWER AREAL CABLES

A. EPR self-supporting areal cables, 600V copper conductors.
B. Triple tandem extrusion process. Excellent deformation resistance.
C. Limited Thermal Stability and Shrink-Back issues for splices and terminations.
D. Long term stability in water.
E. AEIC Qualified – Impulse Test.
F. ICEA Standard Corona test.
G. Messenger cables copper clad, galvanized steel.
H. Rounded Copper Binder Strap.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

D. Feeders shall be rated 90 Degree C insulation.

E. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.
3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. VFC Output Circuits: Type XHHW-2 in metal conduit Type TC-ER cable with braided shield.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
F. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

G. Complete cable tray systems installation according to Section 26 05 36 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.
   1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
   2. Perform each of the following visual and electrical tests:
      a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
      b. Test bolted connections for high resistance using one of the following:
         1) A low-resistance ohmmeter.
2) Calibrated torque wrench.
3) Thermographic survey.
c. Inspect compression-applied connectors for correct cable match and indentation.
d. Inspect for correct identification.
e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports to record the following:
1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION
SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Foundation steel electrodes.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:
   1. Product Data: For each conductor and cable indicating lead content. Lead Content: Less than 300 parts per million.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Test wells.
   2. Ground rods.
   3. Ground rings.
   4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
   1. Include the following:
      a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
         1) Test wells.
         2) Ground rods.
         3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.
   b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NFPA 70B.
      1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      2) Include recommended testing intervals.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

   B. Comply with UL 467 for grounding and bonding materials and equipment.

2.02 MANUFACTURERS

   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1. Burndy; Part of Hubbell Electrical Systems.
      2. ERICO International Corporation.
      3. ILSCO.
      4. O-Z/Gedney; a brand of Emerson Industrial Automation.
      5. SIEMENS Industry, Inc.; Energy Management Division.
      6. Thomas & Betts Corporation; A Member of the ABB Group.
      7. Or approved equal.

2.03 CONDUCTORS

   A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

   B. Bare Copper Conductors:
      4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
      5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
      6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

   C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting...
shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.04 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal two-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:
   1. Mechanical type, two pieces with zinc-plated bolts.
      b. Listed for direct burial.
   2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.
2.05 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
   1. Bury at least 24 inches below grade.
   2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.02 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.03 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Transformer secondary: Install grounding conductor(s) at the transformer secondary WYE connection to the equipment grounding bus bar.
3.04 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a water-proof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with water-proof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and non-current-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.05 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at...
equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

G. Metallic Fences: Comply with requirements of IEEE C2.
   1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
   2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
   3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.06 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
   1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2. Use exothermic welds for all below-grade connections.
   3. For grounding electrode system, install at least three rods spaced at least two-rod lengths from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.
   1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor. All ground test wells shall be accessible for testing.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main...
water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.

2. Bury ground ring not less than 24 inches from building's foundation.

I. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to CEC 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building’s grounding grid or to grounding electrode external to concrete.

J. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.

2. Make connections with clean, bare metal at points of contact.


5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance no fewer than two full calendar days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:
   1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
   2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
   3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
   4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Nonmetallic slotted support systems.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

B. Related Requirements:
1. Section 26 05 48.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.03 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Items penetrating finished ceiling, including the following:
   a. Luminaires.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
   2. Component Importance Factor: 1.5.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch diameter holes at a maximum of 8 inches o.c. in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Allied Tube & Conduit; a part of Atkore International.
      b. B-line, an Eaton business.
      c. Thomas & Betts Corporation; A Member of the ABB Group.
      d. Unistrut; Part of Atkore International.
      e. Or approved equal.
   2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   4. Channel Width: Selected for applicable load criteria.
   5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
      a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
         1) B-line, an Eaton business.
         2) Hilti, Inc.
         3) Or approved equal.
   2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   5. Toggle Bolts: All-steel springhead type.

2.03 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 05 50 00 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA 1.
   2. NECA 101
   3. NECA 102.
   4. NECA 105.

B. Comply with requirements for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacing that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 50 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 05 50 00 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.
3.04  CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-calendar day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in the drawings.

C. Anchor equipment to concrete base as follows:
   1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05  PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

C. Follow painting requirement of Specification Section 09 90 00 – Painting.

END OF SECTION
SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Surface raceways.
5. Boxes, enclosures, and cabinets.
6. Handholes and boxes for exterior underground cabling.

B. Related Requirements:
1. Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section specifications for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.03 DEFINITIONS

A. ARC: Aluminum rigid conduit.
B. GRC: Galvanized rigid steel conduit.
C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Sustainable Design Submittals:
1. Product Data: For solvents and adhesives, indicating VOC content.
2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. VOC Content: 510 g/L or less for PVC conduit and fittings.
B. Samples: For wireways and surface raceways and for each color and texture specified, 12 inches long.

C. Shop Drawing: A single submittal is required for all products covered by this Section. For custom enclosures and cabinets, include plans, elevations, sections, and attachment details.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
   1. Structural members in paths of conduit groups with common supports.
   2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
   3. Where raceways are crossing exposed ceiling spaces visible to the building occupants and where indicated on plans.

B. Qualification Data: For professional engineer.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.01 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. AFC Cable Systems; a part of Atkore International.
      b. Allied Tube & Conduit; a part of Atkore International.
      c. Cal conduit.
      d. Electri-Flex Company.
      e. FSR Inc.
      f. O-Z/Gedney; a brand of Emerson Industrial Automation.
      g. Patriot Aluminum Products, LLC.
      h. Thomas & Betts Corporation; A Member of the ABB Group.
      i. Western Tube and Conduit Corporation.
      j. Wheatland Tube Company.
      k. Or approved equal.
   2. Listing and Labeling: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
   3. GRC: Comply with ANSI C80.1 and UL 6.
   4. IMC: Comply with ANSI C80.6 and UL 1242.
   5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
      a. Comply with NEMA RN 1.
      b. Coating Thickness: 0.040 inch, minimum.
   6. EMT: Comply with ANSI C80.3 and UL 797.
   7. FMC: Comply with UL 1; zinc-coated steel.
   8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
B. Metal Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Allied Tube & Conduit; a part of Atkore International.
   c. Anamet Electrical, Inc.
   d. FSR Inc.
   e. O-Z/Gedney; a brand of Emerson Industrial Automation.
   f. Thomas & Betts Corporation; A Member of the ABB Group.
   g. Western Tube and Conduit Corporation.
   h. Wheatland Tube Company.
   i. Or approved equal.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
   a. Material: Steel.
   b. Type: Setscrew or compression.
7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in CEC 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Arnco Corporation.
   c. CANTEX INC.
   d. Electri-Flex Company.
   e. RACO; Hubbell.
   f. Thomas & Betts Corporation; A Member of the ABB Group.
   g. Or approved equal.
2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ENT: Comply with NEMA TC 13 and UL 1653.
4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
5. LFNC: Comply with UL 1660.

B. Nonmetallic Fittings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. AFC Cable Systems; a part of Atkore International.
   b. Arnco Corporation.
   c. CANTEX INC.
   d. FRE Composites.
   e. RACO; Hubbell.
   f. Thomas & Betts Corporation; A Member of the ABB Group.
   g. Or approved equal.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
   a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.03 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. Hoffman; a brand of Pentair Equipment Protection.
   3. MonoSystems, Inc.
   4. Square D.
   5. Or approved equal.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 3R unless otherwise indicated, and sized according to CEC 70.
   1. Metal wireways installed outdoors shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.
2.04 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer’s standard enamel finish in color selected by Architect. 
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hubbell Incorporated; Wiring Device-Kellems.
      b. MonoSystems, Inc.
      c. Panduit Corp.
      d. Wiremold / Legrand.
      e. Or approved equal.

C. Surface Aluminum Raceways: Alloy 6063-T5 extruded aluminum, minimum thickness 0.050 inches. Satin, No. 204 clear anodized, 0.004 inch thick, Class R1 Mil-Spec finish. Device cover plates suitable to mount commercially available duplex devices, single 1.40 inch and 1.59 inch diameter receptacles, GFCI, surge receptacles and other rectangular faced devices, and voice and data jacks. Devices shall be mounted to cover plates held in place by extruded protrusions. Cover plates shall be removable using standard screwdriver without marring the finish.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Thomas & Betts Corporation.
      c. Wiremold Company (The); Electrical Sales Division 
      d. Or approved equal.

2.05 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Adalet.
   3. EGS/Appleton Electric. 
   5. FSR Inc.
   6. Hoffman; a brand of Pentair Equipment Protection.
   8. Hubbell Incorporated; Wiring Device-Kellems.
   10. MonoSystems, Inc.
   11. Oldcastle Enclosure Solutions.
   13. RACO; Hubbell.
   14. Spring City Electrical Manufacturing Company.
   15. Thomas & Betts Manufacturing Company; A Member of the ABB Group.
   16. Wiremold / Legrand.
17. Or approved equal.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal pressed Outlet and Device Boxes with not welded edges: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:
   1. Type FB01, Multi-service flush mounted floor box with UL scrub water approved.
      a. Material: Cast metal.
      b. Type: Fully adjustable.
      c. Shape: Rectangular.
      d. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Type FB20, Recessed multi-service flush mounted box with hinged cover and cord access flap with UL scrub water approved label.
      a. Material: Cast metal.
      b. Type: Fully adjustable.
      c. Shape: Rectangular.
      d. Size: 10"x12"x6" Deep
      e. Knock-out fittings: (8) ¾", (12) concentric 1"/1¼"/1½"
      f. Cover: as selected by Architect

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

L. Gangable boxes are prohibited.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4. Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer’s standard enamel.

N. Cabinets:
1. NEMA 250, Type 1, Type 3R, Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer’s standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.06 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:
1. Boxes and handholes for use in underground systems shall be designed and identified as defined in CEC 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in CEC 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Armorcast Products Company.
   b. NewBasis.
   c. Oldcastle Enclosure Solutions.
   d. Oldcastle Precast, Inc.
   e. Quazite: Hubbell Power Systems, Inc.
   f. Or approved equal.
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, “ELECTRIC.”.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.07 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed Conduit: GRC.
   2. Concealed Conduit, Aboveground: GRC IMC EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
   6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed, Not Subject to Severe Physical Damage: EMT.
   3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
      a. Loading dock.
      b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
      c. Mechanical rooms.
      d. Gymnasiums.
   4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   6. Damp or Wet Locations: IMC.
   7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Interior Raceway Size: 3/4-inch trade size.


E. Raceway Fittings: Compatible with raceways and suitable for use and location.
   1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
   2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
   3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
   4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>RACEWAYS</th>
<th>BOXES, ENCLOSURES, AND CABINETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry locations concealed</td>
<td>RMC, IMC, EMT, FMC, LFMC, WW</td>
<td>SM, FS/FD; NEMA 1</td>
</tr>
<tr>
<td>Dry locations, exposed, subject to damage*</td>
<td>RMC, IMC</td>
<td>SM, FS/FD; NEMA 1</td>
</tr>
<tr>
<td>Dry locations, exposed, not subject to damage*</td>
<td>RMC, IMC</td>
<td>NEMA 1</td>
</tr>
</tbody>
</table>

**F.** Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in non-metallic sleeve.

**G.** Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

**H.** Install surface raceways only where indicated on Drawings.

**I.** Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

**3.02 RACEWAY SEPARATION OF SYSTEM WIRING**

**A.** Provide minimum separations between power and wiring and signal system wiring as indicated in table above. Where minimum separation cannot be maintained due to existing conditions obtain written permission for closer spacing.
<table>
<thead>
<tr>
<th>ENVIRONMENT</th>
<th>RACEWAYS</th>
<th>BOXES, ENCLOSURES, AND CABINETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet locations, subject to damage</td>
<td>RMC³, IMC³; RMC³, IMC³, EMT³, LFMC, WW⁷</td>
<td>FS/FD; NEMA 4, 4X</td>
</tr>
<tr>
<td>Wet locations, not subject to damage</td>
<td>RMC³, IMC³, EMT³, LFMC, WW⁷</td>
<td>FS/FD; NEMA 4, 4X</td>
</tr>
<tr>
<td>Outdoor locations, exposed to rain, sleet, windblown dust, and external</td>
<td>RMC³, IMC³, PVC</td>
<td>FS/FD; NEMA 3, 3R, 3S</td>
</tr>
<tr>
<td>icing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor locations, underground</td>
<td>RMC³, IMC³, PVC</td>
<td>NEMA 6, 6P</td>
</tr>
<tr>
<td>Outdoor locations, submerged</td>
<td>RMC³, IMC³, PVC</td>
<td>FS/FD</td>
</tr>
<tr>
<td>Outdoor locations embedded in concrete</td>
<td>RMC, IMC, PVC, LFMC</td>
<td>N/A</td>
</tr>
<tr>
<td>Under concrete slab</td>
<td>RMC, IMC, PVC</td>
<td>SCTE 77</td>
</tr>
<tr>
<td>Underground, direct burial</td>
<td>RMC³, IMC³, PVC</td>
<td>N/A</td>
</tr>
<tr>
<td>Embedded burial</td>
<td>RMC, IMC, PVC</td>
<td>N/A</td>
</tr>
<tr>
<td>Industrial location, general</td>
<td>RMC, IMC, EMT⁴, PVC</td>
<td>N/A</td>
</tr>
<tr>
<td>Industrial location, subject to corrosion</td>
<td>RMC, IMC, PVC</td>
<td>FS/FD, SM; NEMA 12, 12K</td>
</tr>
<tr>
<td>Industrial location, subject to oil and vapors</td>
<td>RMC³, IMC³, LFMC</td>
<td>NEMA 4X, 11</td>
</tr>
<tr>
<td>Hazardous Class I, Division 1</td>
<td>RMC, IMC, LFMC</td>
<td>FS/DF; NEMA 13</td>
</tr>
<tr>
<td>Hazardous Class I, Division 1</td>
<td>RMC, IMC, LFMC</td>
<td>NEMA 7, 8</td>
</tr>
<tr>
<td>Hazardous Class I, Division 1</td>
<td></td>
<td>FS/DF; NEMA 1, 7, 8, 12</td>
</tr>
<tr>
<td>ENVIRONMENT</td>
<td>RACEWAYS</td>
<td>BOXES, ENCLOSURES, AND CABINETS</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>2&lt;sup&gt;8&lt;/sup&gt; Hazardous Class II, Division 1</td>
<td>FMC&lt;sup&gt;11&lt;/sup&gt;, WW&lt;sup&gt;5&lt;/sup&gt;</td>
<td>N/A</td>
</tr>
<tr>
<td>Hazardous Class II, Division 2&lt;sup&gt;8&lt;/sup&gt;</td>
<td>RMC, IMC, LFMC</td>
<td>NEMA 9</td>
</tr>
<tr>
<td>Hazardous Class III&lt;sup&gt;8&lt;/sup&gt;</td>
<td>RMC, IMC, LFMC, WW&lt;sup&gt;6&lt;/sup&gt;</td>
<td>FS/FD; NEMA 1, 9, 12</td>
</tr>
<tr>
<td></td>
<td>RMC, IMC, LFMC, WW&lt;sup&gt;6&lt;/sup&gt;</td>
<td>FS/FD; NEMA 12</td>
</tr>
</tbody>
</table>

Notes:
1. Building finishes must provide a barrier with a 15-minute fire rating.
2. For buildings not more than three stories above grade.
3. Corrosion protection is required.
4. With fittings for purpose.
5. Enclosed and gasketed.
6. Dust-tight wireway only.
7. Raintight wireway only.
8. Nonincendive and intrinsically safe wiring are allowed in any wiring method permitted for unclassified locations.
9. Aluminum materials are permitted only with approved supplementary corrosion protection.
10. Schedule 80.
11. Only as specifically permitted under the environmental condition.
12. Subject to temperature.

Legend:
- EMT Electrical metallic tubing
- ENT Electrical non-metallic tubing
- FMC Flexible metal conduit
- FS/FD Cast-metal box
- HDPE High-density polyethylene conduit
- IMC Intermediate metal conduit
- LFMC Liquidtight flexible metal conduit
- LFNC Liquidtight flexible nonmetallic conduit
- N/A Not applicable
- NEMA Refers to NEMA 250, type classification
- NM Nonmetallic box
- PVC Rigid polyvinyl chloride conduit
- RMC Rigid metal conduit
- RTRC Reinforced thermosetting resin conduit
- SM Sheet-metal box
- WW Wireway
3.03 INSTALLATION

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with CEC 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not fasten conduits onto the bottom side of a metal deck roof.

D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Complete raceway installation before starting conductor installation.

F. Arrange stub-ups so curved portions of bends are not visible above finished slab.

G. Install, for 70 volt and above, no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

H. Install, for below 70 volt raceways, no more than the equivalent of two 90-degree bends in any conduit run. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.
L. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforce-
   ment. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforce-
   ment at maximum 10-foot intervals.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all direc-
      tions.
   4. Do not embed threadless fittings in concrete unless specifically approved by Ar-
      chitect for each specific location.
   5. Change from RNC, Type EPC-40-PVC, to GRC before rising above floor.

M. Stub-ups to Above Recessed Ceilings:
   1. Use EMT, IMC, or RMC for raceways.
   2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in
      hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions:
   Apply listed compound to threads of raceway and fittings before making up joints. Fol-
   low compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive
   compound prior to assembly.

P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside
   of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insu-
   lated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated
   with locknuts. Install insulated throat metal grounding bushings on service conduits.

Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. In-
   stall locknuts hand tight plus 1/4 turn more.

R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove
   coatings in the locknut area prior to assembling conduit to enclosure to assure a con-
   tinuous ground path.

S. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use
   roll cutter or a guide to make cut straight and perpendicular to the length.

T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line
   with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end
   of pull wire. Cap underground raceways designated as spare above grade alongside
   raceways in use.

U. Surface Raceways:
   1. Install surface raceway with a minimum 2-inch radius control at bend points.
   2. Secure surface raceway with screws or other anchor-type devices at intervals not
      exceeding 48 inches and with no less than two supports per straight raceway
      section. Support surface raceway according to manufacturer’s written instruc-
      tions. Tape and glue are not acceptable support methods.
V. Install raceway sealing fittings at accessible locations according to CEC 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to CEC 70.

W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by CEC 70.

X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Y. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   b. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
   c. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.
AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

CC. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

DD. Locate boxes so that cover or plate will not span different building finishes.

EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

GG. Set metal floor boxes level and flush with finished floor surface.

HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.04 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Branch Circuit Conduit (600 V and below):
   1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 31 20 00 "Earth Moving" for pipe less than 6 inches in nominal diameter.
   2. Install backfill as specified in Section 31 20 00 "Earth Moving."
   3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 31 20 00 "Earth Moving."
   4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
      a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
      b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
   5. Underground Warning Tape: Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" and follow warning label colors per code.
3.05 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements related to "Penetration Firestopping."

3.08 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION
SECTION 26 05 43
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
   2. Rigid nonmetallic duct.
   3. Flexible nonmetallic duct.
   4. Duct accessories.
   5. Precast concrete handholes.
   6. Polymer concrete handholes and boxes with polymer concrete cover.
   7. Fiberglass handholes and boxes with polymer concrete cover.
   8. Fiberglass handholes and boxes.
   9. High-density plastic boxes.

1.03 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:
   1. Two or more ducts installed in parallel, with or without additional casing materials.
   2. Multiple duct banks.

D. GRC: Galvanized rigid (steel) conduit.

E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.04 ACTION SUBMITTALS

A. Sustainable Design Submittals:
   1. Product Data: For each type of product
   2. For adhesives and sealants, indicating VOC content
3. Include duct-bank materials, including separators and miscellaneous components.
4. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
5. Include accessories for handholes, boxes, and other utility structures.
6. Include warning tape.
7. 
8. Shop Drawing: A single submittal is required for all products covered by this Section.
9. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
10. Include duct entry provisions, including locations and duct sizes.
11. Include cover design.
12. Include grounding details.
13. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
14. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Field quality-control reports.

1.06 MAINTENANCE MATERIALS SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.07 FIELD CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by City or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager no fewer than two calendar days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without City’s written permission.

B. Ground Water: Assume ground-water level is 36 inches below ground surface unless a higher water table is noted on Drawings.
PART 2 - PRODUCTS

2.01 CONDUIT


B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.02 NONMETALLIC DUCTS AND DUCT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. ARNCO Corp.
   2. CANTEX INC.
   4. Or approved equal.

B. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3 by same manufacturer as the duct.

C. Duct Accessories:
   1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.

2.03 FLEXIBLE NONMETALLIC DUCTS

A. HDPE Duct: Type EPEC-80 HDPE, complying with NEMA TC 7 and UL 651A.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. ARNCO Corp.
      b. Carlon; a brand of Thomas & Betts Corporation.
      d. Opti-Com Manufacturing Network, Inc (OMNI).
      e. Premier Conduit.
      f. Or approved equal.
   2. Listed and labeled as defined in CEC 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2.04 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Allied Tube & Conduit; a part of Atkore International.
      b. CANTEX INC.
      c. Carlon; a brand of Thomas & Betts Corporation.
      d. IPEX USA LLC.
      e. PenCell Plastics.
      f. Underground Devices, Inc.
      g. Or approved equal.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 05 53 "Identification for Electrical Systems."

2.05 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Christy Concrete Products.
   2. Oldcastle Precast, Inc.
   3. Utility Concrete Products, LLC.
   5. Or approved equal.

C. Comply with ASTM C 858 for design and manufacturing processes.

D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

F. Cover Legend: Molded lettering, as indicated for each service.

G. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

H. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
   1. Extension shall provide increased depth of 12 inches.
   2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

J. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
   1. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
   2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
   3. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
   4. Knockout panels shall be 1-1/2 to 2 inches thick.

K. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.06 POLYMER CONCRETE HANDEHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Armorcast Products Company.
   2. NewBasis.
   3. Oldcastle Enclosure Solutions.
   4. Or approved equal.


D. Color: Gray.

E. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.

F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, as indicated for each service.

I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
J. Handholes 12 inches wide by 24 inches long and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.07 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carder Concrete Products.
2. Christy Concrete Products.
3. Oldcastle Precast, Inc.
4. Utility Concrete Products, LLC.
5. Utility Vault Co.
6. Or approved equal.

C. Comply with ASTM C 858.

D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches vertically and horizontally to accommodate alignment variations.
1. Center window location.
2. Knockout panels shall be located no less than 6 inches from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches thick.

F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

G. Ground Rod Sleeve: Provide a 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the duct entering the structure.

H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
2.08 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Campbell Foundry Company.
2. Christy Concrete Products.
3. Oldcastle Precast, Inc.
4. Utility Concrete Products, LLC.
5. Utility Vault Co.
6. Or approved equal.

C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches.
   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
2. Cover Legend: Cast in. Selected to suit system.
   a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
   b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
   a. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.


E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch-diameter eye, and 1-by-4-inch bolt.
1. Working Load Embedded in 6-Inch, 4000-psi Concrete: 13,000-lbf minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch-diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf shear and 60,000-lbf tension.
G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch ID by 2-3/4 inches deep, flared to 1-1/4 inches minimum at base.
   1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.

H. Ground Rod Sleeve: 3-inch PVC sleeve in manhole floors 2 inches from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel wedge type with stainless-steel expander clip with 1/2-inch bolt, 5300-lbf rated pullout strength, and minimum 6800-lbf rated shear strength.

J. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.
   1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches in width by nominal 24 inches long; punched with 14 hook holes on 1-1/2-inch centers for cable-arm attachment.
   2. Arms: 1-1/2 inches wide, lengths ranging from 3 inches with 450-lb minimum capacity to 18 inches with 250-lb minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin.

M. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two required.

2.09 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.
   1. Tests of materials shall be performed by an independent testing agency.
   2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
   3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.
PART 3 - EXECUTION

3.01 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved equal by Architect.

C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 31 10 00 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 31 10 00 "Site Clearing."

3.02 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80-PVC, in concrete-encased duct bank unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.


E. Stub-ups: Concrete-encased GRC.

3.03 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:
   1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
   2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
   4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
   5. Cover design load shall not exceed the design load of the handhole or box.
B. Manholes: Precast or cast-in-place concrete.
   1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
   2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.04 EARTHWORK
A. Excavation and Backfill: Comply with Section 31 20 00 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
B. Restoration: Replace area immediately after backfilling is completed and after construction vehicle traffic in immediate area is complete.
C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 92 00 "Turf and Grasses" and Section 32 93 00 "Plants."

3.05 DUCT AND DUCT-BANK INSTALLATION
A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
B. Install duct according to NEMA TCB 2.
C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 12.5 feet, both horizontally and vertically, at other locations unless otherwise indicated.
E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches o.c. for 5-inch duct, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell, without reducing duct slope and without forming a trap in the line.
   2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
   1. Begin change from regular spacing to terminator spacing 10 feet from the terminator, without reducing duct line slope and without forming a trap in the line.
   2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.


L. Concrete-Encased Ducts and Duct Bank:
   1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 20 00 "Earth Moving" for pipes less than 6 inches in nominal diameter.
   2. Width: Excavate trench 3 inches wider than duct on each side.
   3. Depth: Install so top of duct envelope is at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
   4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
   5. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
6. Minimum Space between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.

7. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.

8. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
   a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
      1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
   c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
      1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.

9. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

10. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.

11. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between duct of like services, and 4 inches between power and communications ducts.

12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
   a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
   b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.

13. Pouring Concrete: Comply with requirements in “Concrete Placement” Article in Section 03 30 00 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:
   1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 20 00 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches in nominal diameter.
   2. Width: Excavate trench 12 inches wider than duct on each side.
3. Depth: Install top of duct at least 36 inches below finished grade unless otherwise indicated.
4. Set elevation of bottom of duct bank below frost line.
5. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Install duct with a minimum of 3 inches between ducts for like services and 6 inches between power and communications duct.
8. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
9. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
   a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
      1) Stub-ups shall be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
   c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
      1) Stub-ups shall be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
10. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 20 00 "Earth Moving" for installation of backfill materials.
   a. Place minimum 6 inches of engineered fill above concrete encasement of duct.

N. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 05 53 "Identification for Electrical Systems" no less than 12 inches above all concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.
3.06 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:
1. Finish interior surfaces with a smooth-troweled finish.
2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches thick, arranged as indicated.
3. Comply with requirements in Section 03 30 00 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.

B. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
3. Install handholes with bottom below frost line, below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes after concrete has cured at least three calendar days. After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three calendar days.

G. Dampproofing: Apply dampproofing to exterior surfaces of manholes after concrete has cured at least three calendar days. Dampproofing materials and installation are specified in Section 07 11 13 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three calendar days.
H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators as required for installation and support of cables and conductors and as indicated.

I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches for manholes and 2 inches for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.07 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.

D. Install handholes and boxes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.08 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
   2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-
long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.

3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.
   1. Sweep floor, removing dirt and debris.
   2. Remove foreign material.

END OF SECTION
SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufactures offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Advance Products & Systems, Inc.
   b. Pipeline Seal and Insulator, Inc.
   c. Or approved equal.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Carbon steel

4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.03 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi, 28-calendar day compressive strength.

D. Packaging: Premixed and factory packaged.

2.04 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2. Sealants shall comply with the testing and product requirements of the California Department of Health Services' Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers”.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."
      b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide [1/4-inch] annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
   4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION
SECTION 26 05 48.16

SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Restraint channel bracings.
   2. Restraint cables.
   4. Mechanical anchor bolts.
   5. Adhesive anchor bolts.

B. Related Requirements:
   1. Section 26 05 29 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
      a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.
   1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.
   3. Seismic- and Wind-Restraint Details:
      a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
      b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:
   1. Control and monitoring panels.
   2. Luminaires.
   3. Panelboards.
   4. Photovoltaic system components.
   5. Switchboards.
   6. Transformers.

B. Qualification Data: For professional engineer and testing agency.

C. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: Refer to Architectural and Structural drawings and specifications.
B. Seismic-Restraint Loading:
1. Site Class as Defined in the IBC: Refer to Architectural and Structural drawings and specifications.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: Refer to Architectural and Structural drawings and specifications.
   a. Component Importance Factor: Refer to Architectural and Structural drawings and specifications.
   b. Component Response Modification Factor: Refer to Architectural and Structural drawings and specifications.
   c. Component Amplification Factor: Refer to Architectural and Structural drawings and specifications.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): Refer to Architectural and Structural drawings and specifications.
4. Design Spectral Response Acceleration at 1.0-Second Period: Refer to Architectural and Structural drawings and specifications.

2.02 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. B-line, an Eaton business.
   2. Hilti, Inc.
   3. Mason Industries, Inc.
   4. Unistrut; Part of Atkore International.
   5. Or approved equal.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.03 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Kinetics Noise Control, Inc.
   2. Vibration & Seismic Technologies, LLC.
   3. Vibration Mountings & Controls, Inc.
   4. Or approved equal.

B. Restraint Cables: ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.
2.04 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. B-line, an Eaton business.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. Or approved equal.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.05 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. B-line, an Eaton business.
   2. Hilti, Inc.
   4. Mason Industries, Inc.
   5. Or approved equal.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.03 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork.

B. Equipment and Hanger Restraints:
   1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer’s recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.04 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION
A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.05 FIELD QUALITY CONTROL
A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Perform the following tests and inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with City, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven calendar days’ advance notice.
   4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
   5. Test to 90 percent of rated proof load of device.
C. Seismic controls will be considered defective if they do not pass tests and inspections.
D. Prepare test and inspection reports.

3.06 ADJUSTING
A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION
SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Color and legend requirements for raceways, conductors, and warning labels and signs.
   2. Labels.
   4. Tapes and stencils.
   5. Tags.
   7. Cable ties.
   9. Fasteners for labels and signs.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70.


C. Comply with ANSI Z535.4 for safety signs and labels.

D. Comply with NFPA 70E and Section 26 05 74 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.02 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.
B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
   1. Color shall be factory applied.
   2. Colors for 208/120-V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   3. Colors for 480/277-V Circuits:
      b. Phase B: Orange.
      c. Phase C: Yellow.
   6. Colors for Isolated Grounds: Green with white stripe.

C. Raceways and Cables Carrying Circuits at More Than 600 V:
   1. Black letters on an orange field.
   2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:
   1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING – CAL/OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:
   1. Black letters on a white field.

2.03 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Panduit Corp.
      c. Seton Identification Products.
      d. Or approved equal.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Brady Corporation.
b. Panduit Corp.
c. Seton Identification Products.
d. Or approved equal.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Brother International Corporation.
   c. Ideal Industries, Inc.
   d. Panduit Corp.
   e. Seton Identification Products.
   f. Or approved equal.
2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multi-color, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. A’n D Cable Products.
   b. Brady Corporation.
   c. Brother International Corporation.
   d. Emedco.
   e. Grafoplast Wire Markers.
   f. HellermannTyton.
   g. Ideal Industries, Inc.
   h. LEM Products Inc.
   i. Marking Services, Inc.
   j. Panduit Corp.
   k. Seton Identification Products.
   l. Or approved equal.
2. Minimum Nominal Size:
   a. 1-1/2 by 6 inches for raceway and conductors
   b. 3-1/2 by 5 inches for equipment.
   c. As required by authorities having jurisdiction.
2.04 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters and that stay in place by gripping action.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Marking Services, Inc.
      c. Panduit Corp.
      d. Or approved equal.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Panduit Corp.
      c. Or approved equal.

2.05 TAPES AND STENCILS

A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. Marking Services, Inc.
      d. Or approved equal.

B. Tape and Stencil: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. LEM Products Inc.
      b. Marking Services, Inc.
      c. Seton Identification Products.
      d. Or approved equal.

C. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
b. Seton Identification Products.
c. Or approved equal.

D. Underground-Line Warning Tape:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. Marking Services, Inc.
   d. Seton Identification Products.
   e. Or approved equal.
2. Tape:
   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.
   c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
3. Color and Printing:
   b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
   c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
4. Tag:
   a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Width: 3 inches.
   c. Overall Thickness: 8 mils.
   d. Foil Core Thickness: 0.35 mil.
   e. Weight: 34 lb/1000 sq. ft.
   f. Tensile according to ASTM D 882: 300 lbf and 12,500 psi.

E. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.06 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Carlton Industries, LP.
c. Marking Services, Inc.
d. Seton Identification Products.
e. Or approved equal.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Marking Services, Inc.
      c. Panduit Corp.
      d. Seton Identification Products.
      e. Or approved equal.

C. Write-on Tags:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
      b. Seton Identification Products.
      c. Or approved equal

2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.07 SIGNS

A. Baked-Enamel Signs:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Carlton Industries, LP.
      b. Marking Services, Inc.
      c. Or approved equal.

   2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.

B. Laminated Acrylic or Melamine Plastic Signs:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Brady Corporation.
      b. Carlton Industries, LP.
      c. Marking Services, Inc.
2.08 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.
4. Or approved equal.

B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.09 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.02 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings,
Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.


J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."
   3. "UPS."

M. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Labels:
   1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

P. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

V. Underground Line Warning Tape:
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
   2. Install underground-line warning tape for direct-buried cables and cables in raceways.

W. Metal Tags:
   1. Place in a location with high visibility and accessibility.

X. Nonmetallic Preprinted Tags:
   1. Place in a location with high visibility and accessibility.

Y. Write-on Tags:
   1. Place in a location with high visibility and accessibility.

Z. Baked-Enamel Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Laminated Acrylic or Melamine Plastic Signs:
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.03 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 10-foot maximum intervals.

D. Accessible Raceways and Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

E. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."
4. "FIRE ALARM"

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around color-coding bands to identify the phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

J. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

L. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

M. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

N. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

O. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

P. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
      a. Controls with external control power connections.


R. Main Electrical Room: Framed with glass protective cover a full size drawing of Project electrical single line diagram including all Project Record changes wall. Where multiple drawings are included in construction documents provide one for each sheet.

S. Operating Instruction Signs: Self-adhesive labels.
T. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.

U. Equipment Identification Labels:
1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Stenciled legend 4 inches high.
3. Equipment to Be Labeled:
   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of an engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Switchboards.
   e. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   f. Emergency system boxes and enclosures.
   g. Enclosed switches.
   h. Enclosed circuit breakers.
   i. Enclosed controllers.
   j. Variable-speed controllers.
   k. Push-button stations.
   l. Power-transfer equipment.
   m. Contactors.
   n. Remote-controlled switches, dimmer modules, and control devices.
   o. Battery-inverter units.
   p. Battery racks.
   q. Power-generating units.
   r. Monitoring and control equipment.
   s. UPS equipment.

END OF SECTION
PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and re-installed.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Short-circuit study input data, including completed computer program input data sheets.
   2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

SECTION 26 05 72

5036005

D-4014 Diablo Valley College P/K Complex
b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Specialist.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.06 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

C. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. SKM Systems Analysis, Inc.
   2. Or approved equal.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor designations and kVA ratings.
   5. Switchboard, switchboard and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
   3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
   4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
   5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.


G. Short-Circuit Study Output:
   1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Equivalent impedance.
   2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. Calculated asymmetrical fault currents:
         1) Based on fault-point X/R ratio.
         2) Based on calculated symmetrical value multiplied by 1.6.
         3) Based on calculated symmetrical value multiplied by 2.7.
   3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Obtain all data necessary for the conduct of the study.
   1. Verify completeness of data supplied on the one-line diagram. Call out any discrepancies to the attention of Architect.
   2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for Project’s overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Obtain electrical power utility impedance at the service.
   3. Power sources and ties.
   4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
   5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
   6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
   7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
   8. Motor horsepower and NEMA MG 1 code letter designation.
   9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.02 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
   1. Electric utility's supply termination point.
   2. Low-voltage switchboard.
   3. Control panels.
   5. Disconnect switches.

3.03 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.04 DEMONSTRATION

A. Train City operating and maintenance personnel in the use of study results.

END OF SECTION
SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
   1. Study results shall be used to determine coordination of series-rated devices.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.
   1. Coordination-study input data, including completed computer program input data sheets.
   2. Study and equipment evaluation reports.
   3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
      a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for prelimi-
nary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Specialist Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. The following parts from the Protective Device Coordination Study Report:
         1) One-line diagram.
         2) Protective device coordination study.
         3) Time-current coordination curves.
      b. Power system data.

1.07 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. SKM Systems Analysis, Inc.
      b. CGI CYME
      c. EDSA Micro Corporation
      d. Or approved equal.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
   1. Optional Features:
      a. Arcing faults.
      b. Simultaneous faults.
      c. Explicit negative sequence.
      d. Mutual coupling in zero sequence.

2.02 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260572 "Overcurrent Protective Device Short-Circuit Study."
F. Protective Device Coordination Study:
   1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
      a. Phase and Ground Relays:
         1) Device tag.
         2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
         3) Recommendations on improved relaying systems, if applicable.
      b. Circuit Breakers:
         1) Adjustable pickups and time delays (long time, short time, ground).
         2) Adjustable time-current characteristic.
         3) Adjustable instantaneous pickup.
         4) Recommendations on improved trip systems, if applicable.
      c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
   2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
   3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
   4. Plot the following listed characteristic curves, as applicable:
      a. Power utility's overcurrent protective device.
      b. Medium-voltage equipment overcurrent relays.
      c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
      d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
      e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
      f. Cables and conductors damage curves.
      g. Ground-fault protective devices.
      h. Motor-starting characteristics and motor damage points.
      i. The largest feeder circuit breaker in each motor-control center and panelboard.
   5. Series rating on equipment is not allowed.
   6. Provide adequate time margins between device characteristics such that selective operation is achieved.
   7. Comments and recommendations for system improvements.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
   1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
   1. To normal system low-voltage load buses where fault current is 10 kA or less.
   2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. Transformer Primary Overcurrent Protective Devices:
   1. Device shall not operate in response to the following:
      a. Inrush current when first energized.
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

G. Motor Protection:
   1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
   2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable...
manufacturers or from listed standards indicating conductor size and short-circuit current.

I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
   1. Electric utility's supply termination point.
   2. Low-voltage switchboard.

L. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short-circuit ratings.
   2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
   3. Any application of series-rated devices shall be allowed.

3.03 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
   1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
   2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
   3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.04 MOTOR-STARTING STUDY

A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.

B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.
3.05 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.
   1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus, three phase and line-to-ground.
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
   8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
   9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  11. Maximum demands from service meters.
  12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  13. Motor horsepower and NEMA MG 1 code letter designation.
  14. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
  15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
  16. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
     a. Special load considerations, including starting inrush currents and frequent starting and stopping.
     b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company’s overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices indicated to be coordinated.
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.06 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing Contract portion.

B. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.07 DEMONSTRATION

A. Engage the Coordination Study Specialist to train City maintenance personnel in the following:
   1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.
   2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
   3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION
SECTION 26 05 74

OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
  1. Arc-flash study input data, including completed computer program input data sheets.
  2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
     a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
1.05 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For Arc-Flash Study Specialist.
   B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.06 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data:
      1. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
      2. Operation and Maintenance Procedures: Provide maintenance procedures for use by City personnel that comply with requirements in NFPA 70E.

1.07 QUALITY ASSURANCE
   A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
   B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
      1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
   C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS
   A. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1. SKM Systems Analysis, Inc.
      2. Or approved equal.
   B. Comply with IEEE 1584 and NFPA 70E.
   C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.02 ARC-FLASH STUDY REPORT CONTENT
   A. Executive summary.
B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:
   1. Protective device designations and ampere ratings.
   2. Cable size and lengths.
   3. Transformer kilovolt ampere (kVA) and voltage ratings.
   4. Motor and generator designations and kVA ratings.
   5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

F. Arc-Flash Study Output:
   1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
      a. Voltage.
      b. Calculated symmetrical fault-current magnitude and angle.
      c. Fault-point X/R ratio.
      d. No AC Decrement (NACD) ratio.
      e. Equivalent impedance.
      f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
      g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

G. Incident Energy and Flash Protection Boundary Calculations:
   1. Arcing fault magnitude.
   2. Protective device clearing time.
   3. Duration of arc.
   5. Working distance.
   6. Incident energy.

H. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.03 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
   1. Location designation.
2. Nominal voltage.
3. Flash protection boundary.
5. Incident energy.
7. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.02 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies:
   1. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

C. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.

F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond three to five cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions
from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).

H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
   1. When the circuit breaker is in a separate enclosure.
   2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.03 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
   2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
   3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.

B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
   1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Obtain electrical power utility impedance at the service.
   3. Power sources and ties.
   4. Short-circuit current at each system bus, three phase and line-to-ground.
   5. Full-load current of all loads.
   6. Voltage level at each bus.
   7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
   8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
   9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
  10. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  11. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
12. Motor horsepower and NEMA MG 1 code letter designation.
13. Low-voltage cable sizes, lengths, number, conductor material and conduit mate-
rial (magnetic or nonmagnetic).

3.04 LABELING

A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
   1. Low-voltage switchboard.
   2. Control panel.

3.05 APPLICATION OF WARNING LABELS

A. Install the arc-fault warning labels under the direct supervision and control of the Arc-
Flash Study Specialist.

3.06 DEMONSTRATION

A. Engage the Arc-Flash Study Specialist to train City maintenance personnel in the po-
tential arc-flash hazards associated with working on energized equipment and the sig-
nificance of the arc-flash warning labels.

END OF SECTION
SECTION 26 09 13
ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:
1. Multifunction meters.
2. Power meters.
3. Circuit meters and monitors.
4. Circuit meters and explorer instruments.
5. Electrical power monitoring system software.
6. Electrical power monitoring and control software.
7. Network configuration software.
8. Monitoring and control of power distribution equipment.
10. Desktop workstations.
11. Portable workstations.
12. Raceways and boxes.

B. Related Requirements:
1. Section 25 50 00 – Building Automation Hardware and Networking

1.03 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.
F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. LAN: Local area network.

H. L-G: Line to ground.

I. L-L: Line to line.

J. L-N: Line to neutral.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.


N. BACnet MSTP: An open protocol for exchange of data over serial networks.


P. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

Q. N-G: Neutral to ground.

R. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

S. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

T. TCP/IP: Transport control protocol/Internet.

U. UPS: Uninterruptible power supply; used both in singular and plural context.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for power monitoring and control.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
   1. Product Data: Indicating that computers used by the system are certified by ENERGY STAR.

C. Shop Drawings: For power monitoring and control equipment.
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
   a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
      1) Location of the meters and gateways, and routing of the connecting wiring.
      2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
4. Network naming and numbering scheme.
5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
7. Surge Suppressors: Data for each device used and where applied.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:
   1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
      e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to do the following:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.

j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.

l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

m. Owner training materials.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power monitoring and control units to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Software licenses.
   3. Software service agreement.
   4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
   5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
   6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
   7. Device address list.
   8. Printout of software application and graphic screens.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
1.09 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
   1. Electrical meters LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
   2. BMS contractor to integrate to these meters to display at the campus existing front end.
   3. Monitoring and Verification of the following load types:
      a. Lighting interior and exterior loads.
      b. Receptacle plug loads.
      c. HVAC and Mechanical loads

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.02 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
   1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.
   2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
   1. ASHRAE 135 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter in-
formation from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

2. Acceptable electric meter protocols listed in order of preference:
   a. BACnet IP
   b. BACnet MS/TP
   c. Modbus IP
   d. Modbus RTU

2.03 POWER METERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Eaton.
   2. General Electric Company.
   3. Schneider Electric USA, Inc.
   5. Or approved equal.

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.
   1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
   2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of minus 13 to 158 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:
   1. Comply with ANSI C12.20, Class 0.5.
   2. Neutral Current Measurement: Not more than 0.65 percent.
   3. Power: 0.6 percent.
   4. Power Factor: 0.5 percent.
   5. Active Energy: 0.6 percent.
   6. Reactive Energy: 2.5 percent.
   7. Frequency: 0.05 percent.
   8. THD: 1.0 percent.
   1. Acceptable electric meter protocols listed in order of preference:
      a. BACnet IP
      b. BACnet MS/TP
F. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display shall include the following:
   a. All meters, including those listed under the following:
      1) Measurements.
      2) THD.
      3) Energy.
      4) Demand.
      5) Minimum and maximum values.
      6) Power demand.

G. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.

H. Meters:
1. Measurements: Instantaneous, in real time, rms to the 15th harmonic.
   a. Voltage: L-L each phase, L-N each phase, and three-phase average.
   b. Current: Each phase, three-phase average, and neutral.
   c. Unbalanced current, L-L V ac and L-N V ac.
   d. Active Power (+/- kW): Each phase and three-phase total.
   e. Reactive Power (+/- kVAR): Each phase and three-phase total.
   f. Apparent Power (+/- kVA): Each phase and three-phase total.
   g. Displacement Power Factor: Each phase and three-phase total.
   h. Distortion Power Factor: Each phase and three-phase total.
   i. Frequency.
2. THD from measurements simultaneously from the same cycle, through 15th harmonic.
   a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
   c. Total demand distortion.
3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.
   a. Active kWh.
   b. Reactive kVARh.
   c. Apparent kVAh.
4. Demand: Present, last, predicted, peak.
   a. Three-phase average current.
   b. Three-phase total active power (kW).
   c. Reactive power (kVAR).
   d. Apparent power (kVA).
5. Minimum and Maximum Values:
   a. L-L and L-N voltages.
   b. Current in each phase.
   c. Power factor.
d. Active power total.
e. Reactive power total.
f. Apparent power total.
g. THD L-L and L-N voltages.
h. THD current in each phase.
i. Frequency.

I. Power Demand, User Selectable:
1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
b. Fixed block that calculates demand at end of the interval.
c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a Synchronization Signal:
a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
b. Provide for synchronizing the demand with the internal clock of this instrument.

J. Meter Face:
1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
3. Provide for the reset of metered peak values.

K. Capacities and Characteristics:
1. Power Supply: 120-V ac, 60 Hz.
2. Circuit Connections:
a. Voltage: Measurements autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
c. Frequency: 45 to 65 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.
2.04 CIRCUIT METERS AND MONITORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Eaton.
   2. General Electric Company.
   3. Schneider Electric USA, Inc.
   5. Or approved equal.

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
   1. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in non-air-conditioned or nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 14 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP52 for the front of the meter, and code of IP30 for the back.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:
   1. Comply with ANSI C12.20, Class 0.5.
   2. For Voltage and Current: 0.5 percent of reading.
   3. For Active Power: 0.2 percent.
   4. For Active and Reactive Energy: ANSI 12.20, Class 0.2.
   5. For Frequency: 0.01 Hz in the range of 45 to 65 Hz.
   6. For Power Factor: 0.2 percent from 0.5 leading to 0.5 lagging.
   7. Acceptable electric meter protocols listed in order of preference:
      a. BACnet IP
      b. BACnet MS/TP
      c. Modbus IP
      d. Modbus RTU

F. Meter Physical Characteristics:
   1. Display: Backlit LCD screen with antiglare and scratch-resistant lens.
   2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values.
   3. Allow user to select a date/time format and the ability to create additional screens for user-specified views and custom quantities without overwriting existing standard screens.

G. Sampling Rate:
1. Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on all voltage and current channels of the meter.

H. Meters shall measure, record with time stamp, calculate, and on request display the following:

1. Measurements: Instantaneous, in real time, rms to the 31st or 63rd harmonic:
   b. Current: Each phase, three-phase average, and neutral.
   c. Active Power (kW): Each phase and three-phase total.
   d. Reactive Power (kVAR): Each phase and three-phase total.
   e. Apparent Power (kVA): Each phase and three-phase total.
   f. Displacement Power Factor: Each phase and three-phase total.
   g. Distortion Power Factor: Each phase and three-phase total.
   h. Frequency.

2. THD from measurements simultaneously from the same cycle, through 31st or 63rd harmonic:
   b. Current: Each phase, three-phase average, and neutral.

3. Energy: Accumulated, indicate in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory. Provide for storing accumulated energy at user-defined intervals, up to three intervals per calendar days.
   a. Active kWh.
   b. Reactive kVARh.
   c. Apparent kVAh.

4. Demand: Three-phase totals, present, predicted, peak.
   a. Average current.
   b. Active power (kW).
   c. Reactive power (kVAR).
   d. Apparent power (kVA).

5. Average, Minimum and Maximum Values:
   a. Record, date and time stamp, and save the minimum and maximum values of all rms metered values since the last reset.

I. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.

2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
   a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
   b. Fixed block that calculates demand at end of the interval.
   c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:
a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.

b. Synchronize demand with receipt of a communication signal. Calculation shall be configurable as either a block or rolling block calculation.

c. Provide for synchronization to the clock in the instrument.

J. Trend Curves: Provide for recording four trend curves at intervals of one minute, one hour, one calendar day, or one month; and forecast values for the trended parameters.

1. Record minimum, maximum, and average values of eight user-selected parameters as follows:
   a. Every second for one minute for the one-minute curve.
   b. Every minute for one hour for the one-hour curve.
   c. Every hour for one calendar day for the one-calendar day curve.
   d. Every calendar day for one month for the one-month curve.

2. Forecast the trended parameters for the following:
   a. The next four hours.
   b. The next four calendar days.

K. Waveform Capture:

1. Steady State Waveform Capture: Manually initiated.
   a. Capture, record with time stamp, and store voltage and current waveforms for two cycles.
   b. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard shall be user configurable.
   c. Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 63rd.
   d. Captured waveforms shall be recorded from actual circuit performance.

2. Disturbance Waveform Capture:
   a. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. Disturbance waveform capture may be initiated manually, by an external contact closure, or by an alarm. The waveform captures shall be user configurable from 185 cycles on 1 channel at 16 points per cycle, to 3 cycles on 6 channels at 128 points per cycle.

L. Disturbance Detection and Alarm:

1. Detect and initiate alarm when detecting voltage or current sag and swell.
   a. Detect disturbance events of less than half-cycle in length, by monitoring and calculating rms magnitude of each half-cycle.
   b. Event detection shall be with user-defined parameters of threshold and delay. The threshold shall be user defined as a fixed or relative set point. With relative set point, the instrument will alarm based on the nominal current or voltage approved equal to its present average value. The instrument shall automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
   c. When detecting an alarm condition:
      1) Initiate disturbance waveform capture.
      2) Record the disturbance parameters into an onboard alarm log with a date and time stamp to the millisecond.
3) Alarm on shall be visible on the display and be transmitted over the data link.

4) Display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event for accepted industry standards.

M. Harmonics Information:

1. Calculate the harmonic magnitudes and angles for each phase voltage and current through the 63rd harmonic. Provide harmonic power flows up to the 41st harmonic for active, reactive, and apparent power.
2. The current and voltage information for all phases shall be obtained simultaneously from the same cycle.
3. Report harmonic information as a percentage of the fundamental or as a percentage of the rms values, as selected by the user.

N. Alarms: Alarm events shall be user definable. Provide a minimum of 40 user-defined alarm conditions.

1. User Configuration Options:
   a. Date and time stamp.
   b. Enable-disable (default) or enable.
   c. Pickup magnitude.
   d. Pickup time delay.
   e. Dropout magnitude.
   f. Dropout time delay.
   g. Alarm type.
   h. Alarm label.
2. The following classes of events shall be available to be programmed as alarm events:
   a. Over/under current.
   b. Over/undervoltage.
   c. Current imbalance.
   d. Phase loss, current.
   e. Phase loss, voltage.
   f. Voltage imbalance.
   g. Over kVA.
   h. Over kW or kVAR into/out of load.
   i. Over/under frequency.
   j. Under power factor, true or displacement.
   k. Over THD.
   l. Over demand, current or power.
   m. Reverse power.
   n. Phase reversal.
   o. Status input change.
   p. End of incremental energy interval.
   q. End of demand interval.
   r. Over/under analog inputs.
   s. Current sag/swell.
   t. Voltage sag/swell.
3. For each over/under metered alarm value, provide for the user to define a pickup, dropout, and delay.

4. The circuit meter and monitor alarms response time shall be not less than one second.
5. Provide for up to four alarms to be combined to give a single result using Boolean algebra operations.

O. EN 50160 Evaluation: Report EN 50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, and detailed information for each abnormal event.

P. Capacities and Characteristics:
   1. Power Supply: 120-V ac, 60 Hz
   2. Circuit Connections:
      a. Voltage: Measurement autoranging, 0- to 600-V ac L-L, 0- to 347-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers, or Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
      b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
      c. Frequency: 45 to 65 Hz.
      d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.05 CIRCUIT METER AND EXPLORER

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Eaton.
   2. General Electric Company.
   3. Schneider Electric USA, Inc.
   5. Or approved equal.

B. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring, control, and power quality explorer; complying with UL 61010-1.
   1. Provide for metering 4-wire Y, 3-wire Y, and 3-wire delta power systems.
   2. Equip the instrument with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in non-air-conditioned or nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP52.
   3. The circuit meter and monitor shall meet UL 61010-1 overvoltage withstand rating of CAT IV.
D. Accuracy to the following plus/minus values:
   1. Voltage and Current Meter: 0.04 percent of reading plus 0.025 percent of full scale.
   2. Power and Energy Meter: 0.075 percent of reading plus 0.025 percent of full scale.
   3. Energy Meter: Comply with ANSI C12.20, Class 0.20.
   4. Frequency Meter: 0.01 Hz in the range of 45 to 67 Hz and accurate to 0.1 Hz in the range of 350 to 450 Hz.
   5. Power Factor: 0.002 from 0.5 leading to 0.5 lagging.

E. Data Links:
   1. Acceptable electric meter protocols listed in order of preference:
      a. BACnet IP
      b. BACnet MS/TP
      c. Modbus IP
      d. Modbus RTU

F. Physical Characteristics:
   1. Display: Backlit LCD screen with antiglare and scratch-resistant lens.
   2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values.
   3. Allow user to select a date/time format and the ability to create additional screens for user-specified views and custom quantities without overwriting existing standard screens.

G. Sampling Rate:
   1. Sample current and voltage to provide rms accuracy to 255th harmonic of the fundamental frequency of 60 Hz.
   2. Continuously sample and record voltage and current at a rate not less than 512 samples per cycle, or 83,333 points per cycle, simultaneously on all voltage and current channels of the meter.

H. Measurements, record with time stamp, and calculate; and, on request, display the following:
   1. Measurements: Instantaneous, in real time, rms to the 63rd harmonic:
      a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, L-N three-phase average, and percent unbalanced.
      b. Current: Each phase, neutral, ground, three-phase average, apparent rms, and percent unbalanced.
      c. Active Power (kW): Each phase and three-phase total.
      d. Reactive Power (kVAR): Each phase and three-phase total.
      e. Apparent Power (kVA): Each phase and three-phase total.
      f. Displacement Power Factor: Each phase and three-phase total.
      g. Distortion Power Factor: Each phase and three-phase total.
      h. Frequency.
      i. K-factor for each phase.
   2. THD from measurements simultaneously from the same cycle, through 255th harmonic:
      b. Current: Each phase, three-phase average, and neutral.
c. Power: Active, reactive, and apparent power including power of up to 41st

3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute val-
ues. Store the values in instrument's nonvolatile memory. Provide for storing ac-
cumulated energy at user-defined intervals, up to three intervals per calendar
day.
   a. Active kWh.
   b. Reactive kVARh.
   c. Apparent kVAh.

4. Demand:
   a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-
   N three-phase average.
      1) Present.
      2) Running average.
      3) Last completed interval.
      4) Peak.
   b. Current: Each phase, three-phase average, and neutral.
      1) Present.
      2) Last completed interval.
      3) Minimum.
      4) Peak.
   c. Active Power (kW): Three-phase totals.
      1) Last completed interval.
      2) Predicted.
      3) Peak.
      4) Coincident with peak kVA demand.
      5) Coincident with peak kVAR demand.
      1) Last completed interval.
      2) Predicted.
      3) Peak.
      4) Coincident with peak kW demand.
      5) Coincident with peak kVA demand.
   e. Apparent Power (kVA): Three-phase totals.
      1) Last completed interval.
      2) Predicted.
      3) Peak.
      4) Coincident with peak kW demand.
      5) Coincident with peak kVA demand.
   f. Distortion Power Factor: Three-phase totals.
      1) Last completed interval.
      2) Predicted.
      3) Peak.
      4) Coincident with peak kW demand.
      5) Coincident with peak kVA demand.

I. Average, Minimum and Maximum Values:
   1. Record, date and time stamp, and save the minimum and maximum values of all
   rms metered values since the last reset.
   2. Record, date and time stamp, and save maximum, minimum and average over a
   user-defined interval for the following metered values:
b. Voltage Unbalance: L-L each phase and L-N each phase.
c. Current: rms each phase, three-phase average, and calculated neutral current.
d. Demand Current: rms each phase and three-phase average.
e. Current: Apparent, rms average.
f. Active Power (kW): Each phase and three-phase total.
g. Reactive Power (kVAR): Each phase and three-phase total.
h. Apparent Power (kVA): Each phase and three-phase total.
i. Demand Active Power: Each phase and three-phase total.
j. Demand Reactive Power: Each phase and three-phase total.
k. Demand Apparent Power: Each phase and three-phase total.
l. Accumulated Energy: MWh, MVAh, and MVARh.
m. Reactive energy (MVARh) by quadrant.
n. Power Factor: Three-phase displacement and distortion power factors.
o. K-factor for each phase.
p. THD L-L and L-N voltages.
q. THD current in each phase and neutral.
r. Frequency.

J. Power Demand, User Selectable:
1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
   a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes. The default setting shall be the 15-minute continuous sliding block.
   b. Fixed block that calculates demand at end of the interval.
   c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
3. Demand Calculation Initiated by a synchronization signal. Synchronize demand with clock in the circuit meter and monitor.
   a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
   b. Synchronize demand with receipt of a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
   c. Provide for synchronization to the clock in the instrument.
4. Record, date and time stamp, and save the following demand values of all rms metered values since the last reset, including the following:
   a. Average demand current, per phase.
   b. Peak demand current, per phase.
   c. Average demand for active power, reactive power, and apparent power.
   d. Predicted demand for active power, reactive power, and apparent power.
   e. Peak demand for active power, reactive power, and apparent power.
K. Trend Curves: Provide for recording four trend curves at intervals of one minute, one hour, one calendar day, or one month; and forecast values for the trended parameters:
   1. Record minimum, maximum, and average values of eight user-selected parameters as follows:
      a. Every second for one minute for the one-minute curve.
      b. Every minute for one hour for the one-hour curve.
      c. Every hour for one calendar day for the one-calendar day curve.
      d. Every calendar day for one month for the one-month curve.
   2. Forecast the trended parameters for the following:
      a. The next four hours.
      b. The next four calendar days.

L. Power Analysis Values:
   1. THD Voltage: L-L each phase, L-N each phase, and L-N three-phase average.
   2. THD Current: Each phase, three-phase average, and neutral current.
   3. Total demand distortion.
   4. K-factor for each phase.
   5. Crest factor, each phase.
   6. Displacement power factor.
   7. Fundamental voltage, magnitude and angle, each phase.
   8. Fundamental currents, magnitude and angle, each phase.
   9. Fundamental active power, each phase and three-phase total.
   10. Fundamental reactive power, each phase and three-phase total.
   11. Harmonic power, each phase and three-phase total.
   12. Phase rotation.
   13. Voltage and current unbalances.
   14. Harmonic magnitudes and angles, each phase.
   15. Distortion power.
   16. Distortion power factor.

M. Waveform Capture:
   1. Steady State Waveform Capture: Manually initiated over the communications network.
      a. Capture, record with time stamp, and store voltage and current waveforms at a user-defined resolution of 16 to 512 samples/cycle for up to 30 seconds.
      b. Capture, record with time stamp, and store 512 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard shall be user configurable.
      c. Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 255th for the following:
         1) Voltage: L-N and L-G each phase.
         2) Current: Of each phase and neutral current.
      d. Captured waveforms shall be recorded from actual circuit performance.
   2. Disturbance Waveform Capture:
      a. Capture, record with time stamp, and store digitally sampled data points for each cycle of each phase voltage. Disturbance waveform capture may be initiated manually, by an external contact closure, or by an alarm. The captured waveform shall be at a user-defined resolution of 16 to 512 samples/cycle per second. The number of pre-alarm cycles shall be adjustable.
3. Waveform samples shall be available for transmission over the communications network, for display, archival, and analysis at computer workstations.

N. Transient Detection.
1. Detect and capture transient voltage surge events up to 10 kV L-L with a duration as short as 200 ns.

O. Flicker Detection.
1. Detect and capture flicker events, defined by IEEE 1453, at three levels: instantaneous, short term, and long term.
2. Display the flicker event as plots of magnitude versus time on semi-log graph background.

P. Sag and Swell Detection and Alarm:
1. Detect and initiate alarm when detecting voltage or current sag and swell.
   a. Detect disturbance events of less than half-cycle in length, by monitoring and calculating rms magnitude of each half-cycle.
   b. Event detection shall be with user-defined parameters of threshold and delay. The threshold shall be user defined as a fixed or relative set point. With relative set point, the instrument will alarm based on the nominal current or voltage equal to its present average value. The instrument shall automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
   c. When detecting an alarm condition:
      1) Initiate disturbance waveform capture.
      2) Initiate 100-ms event recording.
      3) Recording the disturbance parameters into an onboard alarm log with a date and time stamp to the millisecond.
      4) Causing an alarm on the display and transmit the alarm over the data link.
      5) The user shall have the ability to display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event for accepted industry standards.

Q. 100-ms Event Recording: Capture, record with time stamp, and store.
1. Initiate recording by an alarm or external contact closure.
2. User-configured recording, to record for the duration of the alarm up to 300 seconds and can be delayed for 1 to 10 seconds.
3. Records current per-phase and neutral, voltage L-L each phase and L-N each phase, active power per-phase and three-phase total, reactive power each phase and three-phase total, apparent power each phase and three-phase total, and true power factor three-phase total.
4. Operate an output relay in the I/O module of the instrument.

R. Harmonics Information:
1. Calculate the harmonic magnitudes and angles for each phase voltage and current in each phase and neutral, through the 255th harmonic. Provide harmonic power flows up to the 41st harmonic for active, reactive, and apparent power.
2. The current and voltage information for all phases shall be obtained simultaneously from the same cycle.
3. Report harmonic information as a percentage of the fundamental or as a percentage of the rms values, as selected by the user.

S. Alarms:
1. Alarm events may be either user defined or preconfigured by manufacturer from the applicable standards. Provide for multiple levels for each alarm that is based on metered data.
2. The instrument shall calculate the listed key electrical parameters at not less than 100-ms intervals to initiate and record an alarm event. Provide for user-selected range of 1 to 10 seconds of pre-event and up to five minutes of post-event data recording.
3. The following classes of events shall be available to be programmed as alarm events:
   a. Over/under current.
   b. Over/undervoltage.
   c. Current imbalance.
   d. Phase loss, current.
   e. Phase loss, voltage.
   f. Voltage imbalance.
   g. Wave shape alarm.
   h. Over kVA.
   i. Over kW or kVAR into/out of load.
   j. Over/under frequency.
   k. Under power factor, true or displacement.
   l. Over THD.
   m. Over K-factor.
   n. Over demand, current or power.
   o. Reverse power.
   p. Phase reversal.
   q. Status input change.
   r. End of incremental energy interval.
   s. End of demand interval.
   t. Over/under analog inputs.
   u. Current sag/swell.
   v. Voltage sag/swell.
   w. Transient events.
4. For each over/under metered alarm value, the user shall define a pickup, dropout, and delay.
5. Waveform Alarms:
   a. The instrument shall detect anomalous waveform events that are less than half-cycle in length.
   b. Provide for the user to set a threshold value and an upper limit to determine whether the waveform triggers an alarm. The threshold value and upper limit shall be a value between 1 and 100. The threshold value is the limit at which a waveform triggers the alarm. The upper limit defines the highest waveform value that triggers a waveform alarm. The settable values are as follows:
      1) Phase voltages.
      2) N-G voltages.
      3) Phase currents.
      4) Neutral currents.
c. In response to a waveform alarm, the instrument shall:
   1) Log the event and record phase currents and voltages as defined in the 100-ms event recording.
   2) Determine the source of the disturbance (upstream or downstream from the meter) and a statistical level of confidence (low, medium, or high) of the accuracy of the source location.

6. Provide four alarm severity levels to allow the user to respond to the most important events first.

7. Indicate an alarm condition on the front panel of the instrument, as well as reported over the data link to designated workstations.

8. The circuit meter and monitor alarms response time shall be not less than the following:
   a. Standard, one second.
   b. High speed, 100 ms.
   c. Disturbance, half-cycle.

9. Up to four alarms may be combined to give a single result using Boolean algebra operations.

10. Provide e-mail notification of alarm conditions.

11. Automatic Alarm Set-Point Adjustment:
   a. The instrument software shall provide for recognizing and learning the characteristics of the normal operation of the electrical power system it is connected to, and to select and adjust alarm set points based on that recognition.
   b. The metered data to be recognized and learned, and the period of time for learning for alarms, disturbances, and waveform alarms, shall be set by the user by selection one of the following two modes:
      1) Fixed Learning: Initially configured user set points are used during the entire learning period.
      2) Dynamic Learning: Initially configured user set points are temporarily replaced by learned set points at the interval specified by the user in the learning setup. The set points continue to be updated at the specified interval until the learning period expires.
   c. The learning period shall be user configurable. If the learned set points do not change over a predefined period, the learning process can be stopped and the set points either installed or held for review.

T. EN 50160 Evaluation: Report EN 50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, and detailed information for each abnormal event.

U. Capacities and Characteristics:
   1. Power Supply: 120-V ac, 60 Hz
   2. Circuit Connections:
      a. Voltage: Measurements autoranging, 0- to 600-V ac L-L, 0- to 347-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers, or Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater.
      b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 15 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
c. Frequency: 45 to 67 Hz, and 350 to 450 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

3. Onboard, Field-Upgradeable, Solid-State Nonvolatile Memory: 8 MB.
4. Number of Onboard Data Logs: 14
5. Number of Minimum/Maximum Log Files: Two
6. Alarm Log Capacity: Not less than 1000 events.
7. Custom Programs: Provide the following programs with the instrument:
   a. Metering of specialized utility rate structures, including real-time pricing and curtailable rates.
   b. Data reduction using smart data logging.
   c. Automatic monthly logging/reset of kWh and peak demand.
   d. Statistical profile analysis of metered quantities.
   e. Calculations for IEEE 519 verification.
   f. Metering of combined utilities: gas, water, steam, and electric.
   g. Non-critical control schemes, such as load control or power factor correction, based on multiple conditions such as time of calendar day and input status.

2.06 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.

   1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
   2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Ethernet Connectivity:
   1. A multipoint, RS-485 Modbus serial communications network shall be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
   2. Serial communications network shall be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network shall be included within the power distribution equipment.
   3. Serial communications devices within the equipment shall be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.

D. Ethernet Gateways:
   1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
   2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
   3. Common Gateway Features:
      a. User configurable, with secure password-protected login process.
      b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information
through embedded HTML web pages for viewing using a standard web browser.

c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's RS-485 port(s) through a standard web browser.

d. Allow firmware upgrades through the communications port.

4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.

5. Implement a common user interface ("look and feel") across all styles of power equipment.

E. Distribution Equipment Monitoring:

1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.

2. Display Data:
   a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).
   b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
   c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
   d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
   e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
   f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
   g. For motor-control centers, the circuit summary web page shall be tailored specifically for this application, to display circuit name, three-phase average rms current, thermal capacity (percentage), drive output frequency (in Hertz, where applicable), and contactor status.

2.07 RACEWAYS AND BOXES

A. Comply with requirements in Section 26.05.33 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

2.08 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 26.05.19 "Low-Voltage Electrical Power Conductors and Cables."
   1. Copper conductors are Type THHN/THWN-2.

B. Control Wiring: Comply with requirements in Section 26.05.23 "Control-Voltage Electrical Power Cables."
1. Optical-Fiber Cable: Multimode, 50/125-micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.

2. Balanced Twisted Pair Cable: 100-ohm, four-pair Category 5e or Category 6.

3. Workstation Outlets: Four-port-connector assemblies mounted in single or multi-gang faceplate. Coordinate color and labels with Section 26 27 26 "Wiring Devices."

4. RS-485 Cable: Paired, one pair or two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.

5. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
   a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
   b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
   c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

C. RS-232 Cable:
   1. PVC-Jacketed, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. Type CM.
      b. Flame Resistance: UL 1581, vertical tray.
   2. Plenum-Type, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      a. Type CMP.

2.09 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. ABB France.
   3. ALLTEC.
   4. Eaton.
   5. Emerson Electric Co.
   6. GE Zenith Controls.
   7. LEA International.
   8. Leviton Manufacturing Co., Inc.
   9. Mersen USA.
   11. Schneider Electric USA, Inc.
   13. Or approved equal.

B. SPDs: Comply with UL 1449, Type 1 or Type 2.
1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V, 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
   1. L-N: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   2. L-G: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   3. N-G: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
   4. L-L: 2000 V for 480Y/277 V, 1200 V for 208Y/120 V.

F. Protection modes and UL 1449 SPD for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
   1. L-N: 700 V.
   2. L-G: 700 V.
   3. N-G: 700 V.
   4. L-L: 1200 V.

G. SCCR: Equal or exceed 100 or 200 kA.

H. Nominal Rating: 20 or 10 kA.

I. Indoor Enclosures: NEMA 250, Type 1.

J. Outdoor Enclosures: NEMA 250, Type 3R, Type 4, Type 4X.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:
   1. Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

E. Raceways Installation:
   1. Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

F. Identification Installation:
   1. Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

3.03 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.04 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

   a. Test Analog Signals:
      1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
      2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
      3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
   b. Test Digital Signals:
      1) Check digital signals using a jumper wire.
      2) Check digital signals using an ohmmeter to test for contact making or breaking.

D. Wiring and cabling will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.06 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when the power monitoring and control system is ready for final review. Written request shall state the following:
   1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
   2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
   3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
   4. The system is complete and ready for final review.

B. Review by Architect and Construction Manager will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

3.07 DEMONSTRATION

A. Demonstrate proper installation of meters and that CTs have been installed correctly for all phases of power.

B. Provide integration support to the BMS contractor for pulling data from the multi-meter cabinets into the existing campus front end.

END OF SECTION
SECTION 26 09 43
DISTRIBUTED LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Digital Lighting Controls
   2. Relay Panels
   3. Emergency Lighting Control (if applicable)

B. Related Sections:
   1. Section 26 27 26 - "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.
   2. Section 26 51 19 - LED Interior Lighting
   3. Section 26 56 19 - LED Exterior Lighting

C. Control Intent – Control Intent includes, but is not limited to:
   1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
   2. Initial sensor and switching zones
   3. Initial time switch settings
   4. Task lighting and receptacle controls
   5. Emergency Lighting control (if applicable)

1.03 QUALITY ASSURANCE

A. Manufacturer: Minimum 10 years’ experience in manufacture of lighting controls.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
      c. Daylighting sensors.
      d. Inwall controls.
   2. Interconnection diagrams showing field-installed wiring.
   3. Include diagrams for power, signal, and control wiring.
1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Structural members to which equipment will be attached.
   3. Items penetrating finished ceiling, including the following:
      a. Luminaires.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.07 WARRANTY

A. Warranty Period: Five year(s) from date of Project acceptance, or as specified per schedule, covering materials and manufacturing defects.

B. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.
   2. Guarantee shall be in accordance with Part IV: General Conditions, Section B: Scope of Work.
   3. Warranty period starts from "Date of Acceptance" by City.
   4. Warranty period of years covering materials and manufacturing defects.
   5. Provide a copy of manufacturer's written warranty statement.
PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION AND OPERATION

A. The Lighting Control and Automation system as defined under this section covers the following equipment:

1. Digital Occupancy Sensors – Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.

2. Digital Switches – Self-configuring, digitally addressable pushbutton on/off, dimming, and scene switches with two-way active infrared (IR) communications.

3. Handheld remotes for personal control – One-button dimming, two-button on/off, or five-button scene remotes provide control using infrared communications. Remote may be configured in the field to control selected loads or scenes without special tools.

4. Digital Daylighting Sensors – Single-zone closed loop, multi-zone open loop and single-zone dual-loop daylighting sensors with two-way active infrared (IR) communications can provide switching, bi-level, tri-level or dimming control for daylight harvesting.

5. Digital Room Controllers – Self-configuring, digitally addressable one, two or three relay plenum-rated controllers for on/off control. Selected models include 0-10 volt or line voltage forward phase control dimming outputs and integral current monitoring capabilities.


7. Configuration Tools – Handheld remote for room configuration and relay panel programming provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow bi-directional communication of room variables and occupancy sensor settings. Computer software also customizes room settings.

8. Digital Lighting Management (DLM) local network – Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.

9. Digital Lighting Management (DLM) segment network – Linear topology, BACnet MS/TP network (1.5 twisted pair, shielded,) to connect multiple DLM local networks for centralized control

10. Network Bridge – provides BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS) and automatically creates BACnet objects representative of connected devices.

11. Segment Manager – provides web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.

12. Programming and Configuration software – Optional PC-native application capable of accessing DLM control parameters within a room, for the local network, via a USB adapter, or globally, for many segment networks simultaneously, via BACnet/IP communication.

13. LMCP Digital Lighting Management Relay Panel – provides up to 8, 24, or 48 mechanically latching relays. Relays include a manual override and a single push-on connector for easy installation or removal from the panel. Panel accepts
program changes from handheld configuration tool for date and time, location, holidays, event scheduling, button binding and group programming. Provides BACnet MS/TP-compliant digital networked communication between other lighting controls and/or building automation system (BAS).

14. Emergency Lighting Control Unit (ELCU) – allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building.

### 2.02 LIGHTING CONTROL APPLICATIONS

A. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:

1. Space Control Requirements – Provide occupancy/vacancy sensors with Manual- or Partial-ON functionality in all spaces except toilet rooms, storerooms, library stacks, or other applications where hands-free operation is desirable and Automatic-ON occupancy sensors are more appropriate. Provide Manual-ON occupancy/vacancy sensors for any enclosed office, conference room, meeting room, open plan system and training room. For spaces with multiple occupants, or where line-of-sight may be obscured, provide ceiling- or corner-mounted sensors and Manual-ON switches.

2. Bi-Level Lighting – Provide multi-level controls in all spaces except toilet rooms, storerooms, library stacks, or applications where variable dimming is used.

3. Task Lighting / Plug Loads – Provide automatic shut off of non essential plug loads and task lighting in all spaces except toilet rooms and storerooms. Provide Automatic-ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.

4. Daylit Areas – Provide daylight-responsive automatic control in all spaces (conditioned or unconditioned) where daylight contribution is available as defined by relevant local building energy code:
   a. All luminaires within code-defined daylight zones shall be controlled separately from luminaires outside of daylit zones.
   b. Daytime setpoints for total ambient illumination (combined daylight and electric light) levels that initiate dimming shall be programmed in compliance with relevant local building energy codes.
   c. Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
   d. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to turn off electric lighting when daylight is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.

5. Conference, meeting, training, auditoriums, and multipurpose rooms shall have controls that allow for independent control of each local control zone. Rooms larger than 300 square feet shall instead have at least four (4) pre-set lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to extinguish all lighting in the space. Spaces with up to four moveable walls shall include controls that can be reconfigured when the room is partitioned.
2.03 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Watt Stopper; or a comparable product by one of the following:
   1. Cooper Industries, Inc.
   2. Lithonia Lighting; Acuity Brands Lighting, Inc.
   3. Crestron, Inc.
   4. Or approved equal.

2.04 DIGITAL LIGHTING CONTROLS

A. Furnish the Company’s system which accommodates the square-footage coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors, switches, daylighting sensors and accessories which suit the lighting and electrical system parameters.

2.05 DIGITAL TIMER SWITCH

A. Digital time switch to automatically turn light off after set time. Adjustable time setting from five minutes to 12 hours. LCD to show time remaining. 20-amp/120 to 277 volt.

B. Wattstopper part number: TS-400.
   1. Finished Spaces: White.
   2. Kitchen Areas and Bathrooms: Gray.
   3. Unfinished Spaces: Gray.
   4. Final finishes as selected by Architect

2.06 DIGITAL WALL SWITCH OCCUPANCY SENSORS

A. Wallbox mounted passive infrared PIR or dual technology (passive infrared and ultrasonic) digital occupancy sensor with 1 or 2 switch buttons.

B. Digital Occupancy Sensors shall provide scrolling LCD display for digital calibration and electronic documentation. Features include the following:
   1. Digital calibration and pushbutton configuration for the following variables:
      a. Sensitivity – 0-100% in 10% increments
      b. Time delay – 1-30 minutes in 1 minute increments
      c. Test mode – Five second time delay
      d. Detection technology – PIR, Dual Technology activation and/or re-activation.
      e. Walk-through mode
      f. Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
   2. Programmable control functionality including:
      a. Each sensor may be programmed to control specific loads within a local network.
      b. Sensor shall be capable of activating one of 16 user-definable lighting scenes.
      c. Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically during the configurable period of time (default 10 seconds) after turning off.
d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
   1) Ultrasonic and Passive Infrared
   2) Ultrasonic or Passive Infrared
   3) Ultrasonic only
   4) Passive Infrared only

3. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.

4. Two RJ-45 ports for connection to DLM local network.

5. Two-way infrared (IR) transceiver to allow remote programming through handheld configuration tool and control by remote personal controls.

6. Device Status LEDs including:
   a. PIR detection
   b. Ultrasonic detection
   c. Configuration mode
   d. Load binding

7. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.

8. Assignment of local buttons to specific loads within the room without wiring or special tools


10. All digital parameter data programmed into an individual wall switch sensor shall be retained in non-volatile FLASH memory within the wall switch sensor itself. Memory shall have an expected life of no less than 10 years.

C. BACnet object information shall be available for the following objects:
   1. Detection state
   2. Occupancy sensor time delay
   3. Occupancy sensor sensitivity, PIR and Ultrasonic
   4. Button state
   5. Switch lock control
   6. Switch lock status

D. Units shall not have any dip switches or potentiometers for field settings.

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

F. Two-button wall switch occupancy sensors, when connected to a single relay dimming room controller, shall operate in the following sequence as a factory default:
   1. Left button
      a. Press and release - Turn load on
      b. Press and hold - Raise dimming load
   2. Right button
      a. Press and release - Turn load off
      b. Press and hold - Lower dimming load
G. Low voltage momentary pushbuttons shall include the following features:
   1. Load/Scene Status LED on each switch button with the following characteristics:
      a. Bi-level LED
      b. Dim locator level indicates power to switch
      c. Bright status level indicates that load or scene is active
   2. The following button attributes may be changed or selected using a wireless
      configuration tool:
      a. Load and Scene button function may be reconfigured for individual buttons
         (from Load to Scene, and vice versa).
      b. Individual button function may be configured to Toggle, On only or Off only.
      c. Individual scenes may be locked to prevent unauthorized change.
      d. Fade Up and Fade Down times for individual scenes may be adjusted from
         0 seconds to 18 hours.
      e. Ramp rate may be adjusted for each dimmer switch.
      f. Switch buttons may be bound to any load on a room controller and are not
         load type dependent; each button may be bound to multiple loads.

H. WattStopper part numbers: LMPW, LMDW. Available in white, light almond, ivory,
grey, red and black; compatible with wall plates with decorator opening.
   1. Third option in "Material for Finished Spaces" Subparagraph below is also
      available in Type 430 but is susceptible to rust and corrosion even in finished
      spaces.
   2. Finished Spaces: White.
   4. Unfinished Spaces: Gray.
   5. Final finishes as selected by Architect.

2.07 DIGITAL WALL OR CEILING MOUNTED OCCUPANCY SENSOR

A. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual
   technology digital (passive infrared and ultrasonic) occupancy sensor.

B. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and
   electronic documentation. Features include the following:
   1. Digital calibration and pushbutton configuration for the following variables:
      a. Sensitivity – 0-100% in 10% increments
      b. Time delay – 1-30 minutes in 1 minute increments
      c. Test mode – Five second time delay
      d. Detection technology – PIR, Ultrasonic or Dual Technology activation
         and/or re-activation.
      e. Walk-through mode
      f. Load parameters including Auto/Manual-ON, blink warning, and daylight
         enable/disable when photosensors are included in the DLM local network.
   2. Programmable control functionality including:
      a. Each sensor may be programmed to control specific loads within a local
         network.
      b. Sensor shall be capable of activating one of 16 user-definable lighting
         scenes.
      c. Adjustable retrigger time period for manual-on loads. Load will retrigger
         (turn on) automatically within a configurable period of time (default 10
         seconds) after turning off.
d. On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
1) Ultrasonic and Passive Infrared
2) Ultrasonic or Passive Infrared
3) Ultrasonic only
4) Passive Infrared only

3. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.

4. One or two RJ-45 port(s) for connection to DLM local network.

5. Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.

6. Device Status LEDs, which may be disabled for selected applications, including:
   a. PIR detection
   b. Ultrasonic detection
   c. Configuration mode
   d. Load binding

7. Assignment of occupancy sensor to a specific load within the room without wiring or special tools.


9. All digital parameter data programmed into an individual occupancy sensor shall be retained in non-volatile FLASH memory within the sensor itself. Memory shall have an expected life of no less than 10 years.

C. BACnet object information shall be available for the following objects:
1. Detection state
2. Occupancy sensor time delay
3. Occupancy sensor sensitivity, PIR and Ultrasonic

D. Units shall not have any dip switches or potentiometers for field settings.

E. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.

F. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC

G. Wattstopper product number (outdoor rated): EW-200.

2.08 DIGITAL WALL SWITCHES

A. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration. Wall switches shall include the following features:
1. Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
3. Configuration LED on each switch that blinks to indicate data transmission.
4. Load/Scene Status LED on each switch button with the following characteristics:
   a. Bi-level LED
b. Dim locator level indicates power to switch

c. Bright status level indicates that load or scene is active

5. Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.

6. Programmable control functionality including:
   a. Button priority may be configured to any BACnet priority level, from 1-16, corresponding to networked operation allowing local actions to utilize life safety priority
   b. Scene patterns may be saved to any button other than dimming rockers. Once set, buttons may be digitally locked to prevent overwriting of the preset levels.

7. All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself. Memory shall have an expected life of no less than 10 years.

B. BACnet object information shall be available for the following objects:
   1. Button state
   2. Switch lock control
   3. Switch lock status

C. Two RJ-45 ports for connection to DLM local network.

D. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration shall be required to achieve multi-way switching.

E. The following switch attributes may be changed or selected using a wireless configuration tool:
   1. Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
   2. Individual button function may be configured to Toggle, On only or Off only.
   3. Individual scenes may be locked to prevent unauthorized change.
   4. Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
   5. Ramp rate may be adjusted for each dimmer switch.
   6. Switch buttons may be bound to any load on a room controller and are not load type dependant; each button may be bound to multiple loads.

   1. Finished Spaces: White.
   2. Kitchen Areas and Bathrooms: Gray.
   3. Unfinished Spaces: Gray.
   4. Final finishes as selected by Architect.
2.09 HANDHELD REMOTE CONTROLS

A. Battery-operated handheld devices in 1, 2 and 5 button configurations for remote switching or dimming control. Remote controls shall include the following features:
   1. Two-way infrared (IR) transceiver for line of sight communication with DLM local network within up to 30 feet.
   2. LED on each button confirms button press.
   3. Load buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.
   4. Inactivity timeout to save battery life.

B. A wall mount holster and mounting hardware shall be included with each remote control.

C. WattStopper part numbers: LMRH-101, LMRH-102, LMRH-105.

2.10 DIGITAL PARTITION CONTROLS

A. Partition controls shall enable manual or automatic coordination of lighting controls in flexible spaces with up to two moveable walls by reconfiguring the connected digital switches and occupancy sensors.

B. Four-button low voltage pushbutton switch for manual control.
   1. Two-way infrared (IR) transceiver for use with configuration remote control.
   2. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   3. Configuration LED on each switch that blinks to indicate data transmission.
   4. Each button represents one wall; Green button LED indicates status.
   5. Two RJ-45 ports for connection to DLM local network.

C. Contact closure interface for automatic control via input from limit switches on movable walls (by others).
   1. Operates on Class 2 power supplied by DLM local network.
   2. Includes 24VDC output and four input terminals for maintained third-party Contract closure inputs.
      a. Input max. sink/source current: 1-5mA
      b. Logic input signal voltage High: >18VDC
      c. Logic input signal voltage Low: <2VDC
   3. Four status LEDs under hinged cover indicate if walls are open or closed; supports LMPS-104 as remote status indicator.
   4. Two RJ-45 ports for connection to DLM local network.
   5. WattStopper part number: LMIO-102

2.11 DIGITAL DAYLIGHTING SENSORS

A. Digital daylighting sensors shall work with room controllers to provide automatic switching, bi-level, or tri-level or dimming daylight harvesting capabilities for any load
Daylighting sensors shall be interchangeable without the need for rewiring.
1. Closed loop sensors measure the ambient light in the space and control a single lighting zone.
2. Open loop sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones.
3. Dual loop sensors measure both ambient and incoming daylight in the space to insure that proper light levels are maintained as changes to reflective materials are made in a single zone.

B. Digital daylighting sensors shall include the following features:
1. The sensor’s internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode’s spectral response curve shall closely match the entire photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
2. Sensor light level range shall be from 1-6,553 footcandles (fc).
3. The capability of ON/OFF, bi-level or tri-level switching, or dimming, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
4. For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the “ON Setpoint” and the “OFF Setpoint” that will prevent the lights from cycling excessively after they turn off.
5. For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a field-selectable minimum level.
6. Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
7. Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off. Selectable range between 0-240 minutes including option to never cut-off.
8. Optional wall switch override shall allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise lighting levels for a selectable period of time or cycle of occupancy.
9. Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
10. Configuration LED status light on device that blinks to indicate data transmission.
11. Status LED indicates test mode, override mode and load binding.
12. Recessed switch on device to turn controlled load(s) ON and OFF.
13. BACnet object information shall be available for the following daylighting sensor objects, based on the specific photocell’s settings:
   a. Light level
   b. Day and night setpoints
   c. Off time delay
   d. On and off setpoints
   e. Up to three zone setpoints
   f. Operating mode – on/off, bi-level, tri-level or dimming
14. One RJ-45 port for connection to DLM local network.
15. A choice of accessories to accommodate multiple mounting methods and building materials. The photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62” thickness (LMLS-400, LMLS-500). Extended tube photosensors accommodate mounting materials from 0.62”-1.25” thickness (LMLS-400-L, LMLS-500-L). Mounting brackets are compatible with J boxes (LMLS-MB1) and wall mounting (LMLS-MB2). LMLS-600 photosensor to be mounted on included bracket below skylight well.

16. Any load or group of loads in the room can be assigned to a daylighting zone
17. Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).
18. All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.

C. Closed loop digital photosensors shall include the following additional features:
   1. An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
   2. Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
   3. Automatically establishes application-specific setpoints following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of loads.
   4. WattStopper Product Number: LMLS-400, LMLS-400-L.

D. Open loop digital photosensors shall include the following additional features:
   1. An internal photodiode that measures light in a 60-degree angle cutting off the unwanted light from the interior of the room.
   2. Automatically establishes application-specific setpoints following manual calibration using a wireless configuration tool or a PC with appropriate software. For switching operation, an adequate deadband between the ON and OFF setpoints for each zone shall prevent the lights from cycling; for dimming operation, a proportional control algorithm shall maintain the design lighting level in each zone.
   3. Each of the three discrete daylight zones can include any non overlapping group of loads in the room.
   4. WattStopper Product Number: LMLS-500, LMLS-500-L.

E. Dual loop digital photosensors shall include the following additional features:
   1. Close loop portion of dual loop device must have an internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from sources outside of this cone
   2. Open loop portion of dual loop device must have an internal photodiode that can measure light in a 60 degree angle, cutting off the unwanted light from the interior of the room.
   3. Automatically establishes application-specific set-points following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding...
setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of load.

4. Device must reference closed loop photosensor information as a base line reference. The device must be able to analyze the open loop photosensor information to determine if an adjustment in light levels is required.

5. Device must be able to automatically commission setpoints each night to provide adjustments to electrical lighting based on changes in overall lighting in the space due to changes in reflectance within the space or changes to daylight contribution based on seasonal changes.

6. Device must include extendable mounting arm to properly position sensor within a skylight well.

7. WattStopper product number LMLS-600

2.12 DIGITAL ROOM CONTROLLERS AND PLUG-LOAD CONTROLLERS

A. Digital controllers for lighting and plug loads automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room and plug load controllers shall be provided to match the room lighting and plug load control requirements. The controllers will be simple to install, and will not have dip switches or potentiometers, or require special configuration for standard Plug n' Go applications. The control units will include the following features:

1. Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.

2. Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.

3. Multiple room controllers connected together in a local network must automatically prioritize each room controller, without requiring any configuration or setup, so that loads are sequentially assigned using room controller device ID’s from highest to lowest.

4. Device Status LEDs to indicate:
   a. Data transmission
   b. Device has power
   c. Status for each load
   d. Configuration status

5. Quick installation features including:
   a. Standard junction box mounting
   b. Quick low voltage connections using standard RJ-45 patch cable

6. Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
   a. Turn on to 100%
   b. Remain off
   c. Turn on to last level

7. Each load shall be configurable to operate in the following sequences based on occupancy:
   a. Auto-on/Auto-off (Follow on and off)
   b. Manual-on/Auto-off (Follow off only)

8. The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.

9. BACnet object information shall be available for the following objects:
   a. Load status
   b. Electrical current
c. Total watts per controller
d. Schedule state – normal or after-hours
e. Demand response control and cap level
f. Room occupancy status
g. Total room lighting and plug loads watts
h. Total room watts/sq ft
i. Force on/off all loads
10. UL 2043 plenum rated
11. Manual override and LED indication for each load
12. Dual voltage (120/277 VAC, 60 Hz), or 347 VAC, 60 Hz (selected models only).
   120/277 volt models rated for 20A total load, derating to 16A required for some
dimmed loads (forward phase dimming); 347 volt models rated for 15A total load;
plug load controllers carry application-specific UL 20 rating for receptacle control.
13. Zero cross circuitry for each load
14. All digital parameter data programmed into an individual room controller or plug
   load controller shall be retained in non-volatile FLASH memory within the
controller itself. Memory shall have an expected life of no less than 10 years.

B. On/Off Room Controllers shall include:
   1. One or two relay configuration
   2. Efficient 150 mA switching power supply
   3. Three RJ-45 DLM local network ports with integral strain relief and dust cover
   4. WattStopper product numbers: LMRC-101, LMRC-102

C. On/Off/Dimming enhanced Room Controllers shall include:
   1. Real time current monitoring
   2. Multiple relay configurations
      a. One, two or three relays (LMRC-21x series)
      b. One or two relays (LMRC-22x series)
   3. Efficient 250 mA switching power supply
   4. Four RJ-45 DLM local network ports with integral strain relief and dust cover
   5. One dimming output per relay
      a. 0-10V Dimming - Where indicated, one 0-10 volt analog output per relay for
         control of compatible ballasts and LED drivers. The 0-10 volt output shall
         automatically open upon loss of power to the Room Controller to assure full
         light output from the controlled lighting. (LMRC-21x series)
      b. Line Voltage, Forward Phase Dimming - Where indicated, one forward
         phase control line voltage dimming output per relay for control of
         compatible two-wire or three-wire ballasts, LED drivers, MLV, forward
         phase compatible ELV, neon/cold cathode and incandescent loads.
         (LMRC-22x series)
      c. Each dimming output channel shall have an independently configurable
         minimum and maximum calibration trim level to set the dimming range to
         match the true dynamic range of the connected ballast or driver.
      d. The LED level indicators on bound dimming switches shall utilize this new
         maximum and minimum trim.
      e. Each dimming output channel shall have an independently configurable
         minimum and maximum trim level to set the dynamic range of the output
         within the new 0-100% dimming range defined by the minimum and
         maximum calibration trim.
      f. Calibration and trim levels must be set per output channel.
g. Devices that set calibration or trim levels per controller are not acceptable.
h. All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.
6. Each load shall have an independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After Hours events.
7. Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.
8. The following dimming attributes may be changed or selected using a wireless configuration tool:
   a. Establish preset level for each load from 0-100%
   b. Set high and low trim for each load
   c. Set lamp burn in time for each load up to 100 hours
9. Override button for each load provides the following functions:
   a. Press and release for on/off control
   b. Press and hold for dimming control
10. WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMRC-221, LMRC-222

D. Plug Load Room Controllers shall include:
   1. One relay configuration with additional connection for unswitched load
   2. Configurable additive time delay to extend plug load time delay beyond occupancy sensor time delay (e.g. a 10 minute additive delay in a space with a 20 minute occupancy sensor delay ensures that plug loads turn off 30 minutes after the space is vacated).
   3. Factory default operation is Auto-on/Auto-off, based on occupancy
   4. Real time current monitoring of both switched and un-switched load (LMPL-201 only)
   5. Efficient switching power supply
      a. 150mA (LMPL-101)
      b. 250mA (LMPL-201)
   6. RJ-45 DLM local network ports
      a. Three RJ-45 ports (LMPL-101)
      b. Four RJ-45 ports (LMPL-201)

2.13 DLM LOCAL NETWORK (ROOM NETWORK)

A. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.

B. Features of the DLM local network include:
   1. Plug n’ Go® automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
   2. Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
   3. Push n’ Learn® configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
4. Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.

C. Digital room devices connect to the local network using pre-terminated Cat 5e cables with RJ-45 connectors, which provide both data and power to room devices. Systems that utilize RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.

D. If manufacturer’s pre-terminated Cat 5e cables are not used for the installation, the Subcontractor is responsible for testing each cable following installation and supplying manufacturer with test results.

E. WattStopper Product Number: LMRJ-Series

2.14 DLM SEGMENT NETWORK (ROOM TO ROOM NETWORK)

A. The segment network shall be a linear topology, BACnet-based MS/TP subnet to connect DLM local networks (rooms) and LMCP relay panels for centralized control.
   1. Each connected DLM local network shall include a single network bridge (LMBC-300), and the network bridge is the only room-based device that is connected to the segment network.
   2. Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate “in” and “out” terminations, for segment network connections.
   3. The segment network shall utilize 1.5 twisted pair, shielded, cable supplied by the lighting control manufacturer. The maximum cable run for each segment is 4,000 feet. Conductor-to-conductor capacitance of the twisted pair shall be less than 30 pf/ft and have a characteristic impedance of 120 Ohms.
   4. Network signal integrity requires that each conductor and ground wire be correctly terminated at every connected device.
   5. Substitution of manufacturer-supplied cable must be pre-approved.
   6. Segment networks shall be capable of connecting to BACnet-compliant BAS (provided by others) either directly, via MS/TP, or through NB-ROUTERs, via BACnet/IP or BACnet/Ethernet. Systems whose room-connected network infrastructure require gateway devices to provide BACnet data to a BAS are unacceptable.

B. WattStopper Product Number: LM-MSTP, LM-MSTP-DB

2.15 CONFIGURATION TOOLS

A. A wireless configuration tool facilitates optional customization of DLM local networks using two-way infrared communications, while PC software connects to each local network via a USB interface.

B. Features and functionality of the wireless configuration tool shall include but not be limited to:
   1. Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
2. High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.

3. Must be able to read and modify parameters for room controllers, occupancy sensors, wall switches, daylighting sensors, network bridges and relay panels, and identify room devices by type and serial number.

4. Save up to eight occupancy sensor setting profiles, and apply profiles to selected sensors.

5. Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.

6. Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.

7. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.

8. Verify status of building level network devices.

C. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100

2.16 NETWORK BRIDGE

A. The network bridge module connects a DLM local network to a BACnet-compliant segment network for communication between rooms, relay panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication and an optically isolated EIA/TIA RS-485 transceiver.

1. The network bridge shall be provided as a separate module connected on the local network through an available RJ-45 port.

2. Provide Plug n’ Go operation to automatically discover room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.

3. The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. BACnet objects will be created for the addition or replacement of any given in-room DLM device for the installed life of the system. Products requiring that an application-specific point database be loaded to create or map BACnet objects are not acceptable. Systems not capable of providing BACnet data for control devices via a dedicated BACnet Device ID and physical MS/TP termination per room are not acceptable. Standard BACnet objects shall be provided as follows:

   a. Read/write the normal or after hours schedule state for the room
   b. Read the detection state of each occupancy sensor
   c. Read the aggregate occupancy state of the room
   d. Read/write the On/Off state of loads
   e. Read/write the dimmed light level of loads
   f. Read the button states of switches
   g. Read total current in amps, and total power in watts through the room controller
h. Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
i. Activate a preset scene for the room
j. Read/write daylight sensor fade time and day and night setpoints
k. Read the current light level, in footcandles, from interior and exterior photosensors and photocells
l. Set daylight sensor operating mode
m. Read/write wall switch lock status
n. Read watts per square foot for the entire controlled room
o. Write maximum light level per load for demand response mode
p. Read/write activation of demand response mode for the room
q. Activate/restore demand response mode for the room

B. WattStopper product numbers: LMBC-300

2.17 SEGMENT MANAGER

A. For networked applications, the Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP traffic via a configurable port (default is 80) or 256 bit AES encrypted SSL TCP/IP traffic via a configurable port (default is 443).

B. Each segment manager shall have integral support for at least three segment networks. Segment networks may alternately be connected to the segment manager via external routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment network. Provide the quantity of routers and switches as shown on the plans.

C. Operational features of the Segment Manager shall include the following:
   1. Connection to PC or LAN via standard Ethernet TCP/IP via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
   2. Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or approved equal browser. Shall not require installation of any lighting control software to an end-user PC.
   3. Log in security capable of restricting some users to view-only or other limited operations.
   4. Automatic discovery of DLM devices and relay panels on the segment network(s). Commissioning beyond activation of the discovery function shall not be required to provide communication, monitoring or control of all local networks and lighting control panels.
   5. After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
   6. Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-On or Auto-On.
   7. Ability to set up schedules for rooms and panels, view and override current status of panel channels and relays, and assign relays to groups. Schedules shall automatically set controlled zones or areas to either a normal hours or after
hours mode of operation. Support for a minimum of 100 unique schedules, each with up to four time events per day. Support for annual schedules, holiday schedules and unique date-bound schedules.

8. Ability to group rooms and loads for common control by schedules, switches or network commands.

9. Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.

10. Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control.

11. The Segment Manager shall allow access and control of the overall system database via Native Niagara AX FOX connectivity. Systems that must utilize a Tridium Niagara controller in addition to the programming, scheduling and configuration server are not acceptable.

D. Segment Manager shall support multiple DLM rooms as follows:
   1. Support up to 120 network bridges and 900 digital in-room devices (LMSM-3E).
   2. Support up to 300 network bridges and 2,200 digital in room devices, connected via network routers and switches (LMSM-6E).


2.18 PROGRAMMING, CONFIGURATION AND DOCUMENTATION SOFTWARE

A. PC-native application for optional programming of detailed technician-level parameter information for all DLM products, including all parameters not accessible via BACnet and the handled IR configuration tool. Software must be capable of accessing room-level parameter information locally within the room when connected via the optional LMCI-100 USB programming adapter, or globally for many segment networks simultaneously utilizing standard BACnet/IP communication.

   1. Additional parameters exposed through this method include but are not limited to:
      a. Occupancy sensor detection LED disable for performance and other aesthetic spaces where blinking LEDs present a distraction.
      b. Six occupancy sensor action behaviors for each controlled load, separately configurable for normal hours and after hours modes. Modes include: No Action, Follow Off Only, Follow On Only, Follow On and Off, Follow On with Override Time Delay, Follow Off Only with Blink Warn Grace Time, Follow On and Off with Blink Warn Grace Time.
      c. Separate fade time adjustments per load for both normal and after hours from 0 - 4 hours.
      d. Configurable occupancy sensor re-trigger grace period from 0 - 4 minutes separate for both normal hours and after hours.
      e. Separate normal hours and after hours per-load button mode with modes including: Do nothing, on only, off only, on and off.
f. Load control polarity reversal so that on events turn loads off and vice versa.

g. Per-load DR (demand response) shed level in units of percent.

h. Load output pulse mode in increments of 1 second.

i. Fade trip point for each load for normal hours and after hours that establishes the dimmer command level at which a switched load closes its relay to allow for staggered On of switched loads in response to a dimmer.

2. Generation of reports at the whole file, partial file, or room level. Reports include but are not limited to:

   a. Device list report: All devices in Project listed by type.
   b. Load binding report: All load controller bindings showing interaction with sensors, switches, and daylighting.
   c. BACnet points report: Per room Device ID report of the valid BACnet points for a given site’s BOM.
   d. Room summary report: Device manifest for each room, aggregated by common BOM, showing basic sequence of operations.
   e. Device parameter report: Per-room lists of all configured parameters accessible via hand held IR programmer for use with O&M documentation.
   f. Scene report: All Project scene pattern values not left at defaults (i.e. 1 = all loads 100%, 2 = all loads 75%, 3 = all loads 50%, 4 = all loads 25%, 5-16 = same as scene 1).
   g. Occupancy sensor report: Basic settings including time delay and sensitivity(ies) for all occupancy sensors.

3. Network-wide programming of parameter data in a spreadsheet-like programming environment including but not limited to the following operations:

   a. Set, copy/paste an entire Project site of sensor time delays.
   b. Set, copy/paste an entire Project site of sensor sensitivity settings.
   c. Search based on room name and text labels.
   d. Filter by product type (i.e. LMRC-212) to allow parameter set by product.
   e. Filter by parameter value to search for product with specific configurations.

4. Network-wide firmware upgrading remotely via the BACnet/IP network.

   b. Mass firmware update of specifically selected rooms or areas.
   c. Mass firmware upgrade of specific products.

B. WattStopper Product Number: LMCS-100, LMCI-100

2.19 LMCP LIGHTING CONTROL PANELS

A. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:

1. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 - 8 relays, 1 - 24 relays and 6 four-pole contactors, or 1 - 48 relays and 6 four-pole contactors.

2. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.

3. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include
intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:

a. Removable, plug-in terminal blocks with connections for all low voltage terminations.

b. Individual terminal block, override pushbutton, and LED status light for each relay.

c. Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.

d. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.

e. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.

f. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.

g. Group and pattern control of relays shall be provided through a simple keypad interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.

h. Relay group status for shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.

i. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:

1) Electrical:
   a) 30 amp ballast at 277V
   b) 20 amp ballast at 347V
   c) 20amp tungsten at 120V
   d) 30 amp resistive at 347V
   e) 1.5 HP motor at 120V
   f) 14,000 amp short circuit current rating (SCCR) at 347V
   g) Relays shall be specifically UL 20 listed for control of plug-loads

2) Mechanical:
   a) Replaceable, ½” KO mounting with removable Class 2 wire harness.
   b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
   c) Dual line and load terminals each support two #14 - #12 solid or stranded conductors.
   d) Tested to 300,000 mechanical on/off cycles.

4. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.
5. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet Project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

6. Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic by pass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article 700.

7. Integral system clock shall provide scheduling capabilities for panel-only Projects without DLM segment networks or BAS control.
   a. Each panel shall include digital clock capability able to issue system wide automation commands to up to (11) eleven other panels for a total of (12) twelve networked lighting control panels. The clock shall provide capability for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.
   b. The clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.
   c. The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for the clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.
   d. The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:
      1) Scheduled ON / OFF
      2) Manual ON / Scheduled OFF
      3) Astro ON / OFF (or Photo ON / OFF)
      4) Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)
   e. The user interface shall be a portable IR handheld remote control capable of programming any panel in the system (LMCT-100)
   f. The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
   g. Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost. Lighting control panels that are not capable of executing events independently of the global network shall not be acceptable.

8. The lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.

9. The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet® protocol.
   a. The panel shall have provision for an individual BACnet device ID and shall support the full $2^{22}$ range (0 – 4,193,304). The device ID description property shall be writable via the network to allow unique identification of the lighting control panel on the network.
b. The panel shall support MS/TP MAC addresses in the range of 0 – 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.

c. Lighting control relays shall be controllable as binary output objects in the instance range of 1 – 64. The state of each relay shall be readable and writable by the BAS via the object present value property.

d. Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 – 64.

e. The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 – 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after-hours mode.

f. Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:
   1) Binary output objects in the instance range of 1 – 64 (one per relay) for on/off control of relays.
   2) Binary value objects in the instance range of 1 – 99 (one per channel) for normal hours/after hours schedule control.
   3) Binary input objects in the instance range of 1 – 64 (one per relay) for reading true on/off state of the relays.
   4) Analog value objects in the instance range of 101 – 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.

g. The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.

h. The BO and BV 1 – 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object described in addendum aa. (http://www.bacnet.org/Addenda/Add-135-2010aa.pdf)

i. Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.

j. Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.

10. WattStopper Product Number: LMCP8, LMCP24 or LMCP48

2.20 USER INTERFACE

A. Each lighting control panel system shall be supplied with at least (1) handheld configuration tool (LMCT-100). As a remote programming interface the configuration
tool shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following panel-specific functions as a minimum:

1. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
2. Relay Group creation of up to 99 groups. Group creation shall result in programming of all seven key relay parameters for member relays. The seven parameters are as follows: After-hours Override Time Delay, Normal Hours Override Time Delay, Action on Transition to Normal Hours, Action on Transition to After Hours, Sensor Action During Normal Hours, Sensor Action During After Hours, Blink-Warn Time for After Hours.
3. Program up to 254 separate scheduled events. Events shall occur on seven calendar day intervals with each calendar day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays. Holidays are also defined through the User Interface.
4. Program up to 32 separate Dark/Light events. Events shall have a selectable source as either calculated Astro with delay, or a digital IO module with an integral 0-5V or 0-10V analog photocell. Dark/Light events shall occur on seven calendar day intervals with each calendar day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays.
5. Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.
6. Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.
7. An additional handheld IR remote may optionally be specified to be permanently mounted to the panel interior via a retractable anti-theft lanyard to allow for convenient programming of the panel while assuring that the handheld programmer is always present at that panel. An unlimited number of handheld IR remotes may also be purchased for facilities staff as determined by the end user’s representative.

B. WattStopper Product Number: LMCT-100

2.21 EMERGENCY LIGHTING CONTROL DEVICES

A. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:

1. 120/277 volts, 50/60 Hz, 20 amp ballast rating
2. Push to test button
3. Auxiliary contact for remote test or fire alarm system interface

B. WattStopper Product Numbers: ELCU-100, ELCU-200.
3.01 PRE-INSTALLATION MEETING

A. A factory authorized manufacturer’s representative shall provide the electrical Subcontractor a functional overview of the lighting control system prior to installation. The Subcontractor shall schedule the pre-installation site visit after receipt of approved submittals to review the following:

1. Discuss final selections of devices, including occupancy sensors, sensor switches, wall mount button control switches with dimmers, etc. Submit to architect and engineer for final approval.
2. Confirm the location and mounting of all digital devices, with special attention to placement of occupancy and daylighting sensors.
3. Review the specifications for low voltage control wiring and termination.
4. Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
5. Discuss requirements for integration with other trades.

3.02 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer’s written instructions.

3.04 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.
3.05 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.06 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.07 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.08 FACTORY SERVICES

A. Upon completion of the installation, the manufacturer's factory authorized representative shall start up and verify a complete fully functional system.
B. The electrical Subcontractor shall provide both the manufacturer and the electrical engineer with three weeks written notice of the system start up and adjustment date.

C. Upon completion of the system start up, the factory-authorized technician shall provide the proper training to the City's personnel on the adjustment and maintenance of the system.

3.09 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
   1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit City's operations.
   2. For daylighting controls, adjust set points and deadband controls to suit City's operations.
   3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.10 ACCEPTANCE TESTING SUPPORT SERVICES

A. A certified lighting controls acceptance test technician (CLCATT) must verify the installation of the lighting control system. Manufacturer should include an extra calendar day of factory technician's time to assist the CLCATT review the functionality and settings of the lighting control hardware per the requirements in the California State forms. It will be the CLCATT's responsibility to create and complete any forms required for the commissioning process, although the manufacturer or Subcontractor may offer spreadsheets and/or printouts to assist the CLCATT with this task.

3.11 COMMISSIONING SUPPORT SERVICES

A. On this Project, a commissioning agent will be hired to verify the installation and programming of all building systems, which includes the lighting control system. Manufacturer should include an extra calendar day of technician's time to review the functionality and settings of the lighting control hardware with the commissioning agent, including reviewing submittal drawings and ensuring that instructions on how to configure each device are readily available. Manufacturer is NOT responsible for helping the commissioning agent inspect the individual devices. It will be the commissioning agent's responsibility to create and complete any forms required for the commissioning process, although the manufacturer or Subcontractor may offer spreadsheets and/or printouts to assist the agent with this task.

B. The commissioning agent shall work with the electrical Subcontractor during installation of the lighting control hardware to become familiar with the specific products. The agent may also accompany the manufacturer's technicians during their start-up work to better understand the process of testing, calibration and configuration of the products. However, the Subcontractor and manufacturer shall ensure that interfacing with the agent does not prevent them from completing the requirements outlined in the subcontract documents.
3.12 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 calendar days to allow City to schedule and access the system and to upgrade computer equipment if necessary.

3.13 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems.

B. Engage a factory-authorized service representative to train City’s maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION
SECTION 26 22 13
LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
   2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
   3. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   4. Certification: Indicate that equipment meets Project and equipment seismic requirements.

C. Coordination
D. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

E. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

F. Source quality-control reports.

G. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Eaton.
5. Hammond Power Solutions Inc.
6. Powersmiths International Corp.
7. Siemens Power Transmission & Distribution, Inc.
8. Sola/Hevi-Duty; a brand of Emerson Electric Co.
9. Square D; by Schneider Electric.
10. Or approved equal.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified."

2.03 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.04 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
1. One leg per phase.
2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
3. Grounded to enclosure.

D. Coils: Continuous windings without splices except for taps.
1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.
E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

F. Indoor Enclosure: Ventilated.
   1. NEMA 250, Type 2: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
   2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
   3. Wiring Compartment: Sized for conduit entry and wiring installation.
   4. Finish: Comply with NEMA 250.
      a. Finish Color: Gray weather-resistant enamel.

G. Outdoor Enclosure: Totally enclosed, nonventilated.
   1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
   2. Wiring Compartment: Sized for conduit entry and wiring installation.
   3. Finish: Comply with NEMA 250.
      a. Finish Color: Gray weather-resistant enamel.

H. Taps for Transformers 3 kVA and Smaller: None.

I. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

J. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

K. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

L. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature.

M. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

N. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
   2. Include special terminal for grounding the shield.

O. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

P. Wall Brackets: Manufacturer's standard brackets.

Q. Fungus Proofing: Permanent fungicidal treatment for coil and core.

R. Low-Source-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
   1. 9 kVA and Less: 45 dB.
   2. 30 to 50 kVA: 45 dB.
3. 51 to 150 kVA: 50 dB.
4. 151 to 300 kVA: 55 dB.
5. 301 to 500 kVA: 60 dB.
6. 501 to 750 kVA: 62 dB.
7. 751 to 1000 kVA: 64 dB.
8. 1001 to 1500 kVA: 65 dB.

2.05 HIGH EFFICIENCY TRANSFORMERS

A. Transformer shall facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads. Meet all national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.

B. Provide copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer(s) built to NEMA ST20 and relevant NEMA, UL and IEEE standards; 200% rated neutral; 60Hz rated.

C. Transformers shall be 750 kVA and less, 600 volt primary and less, shall be UL Listed and Labeled. All terminals, including those for changing taps, must be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded. 10kV BIL.

D. Insulation System:
   1. Insulation system shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long life expectancy.
   2. Class: 220 degrees C.
   4. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
   5. Water absorption (24hrs @25C): less than 0.05% (superior insulation, longer life)
   6. Chemical Resistance: Must have documented excellent performance rating by supplier
   7. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
   8. Dissipation Factor: max. 0.02 @25C to reduce aging of insulation, extending useful life

E. Operating Temperature Rise: 130 degree C in a 40 degree C maximum ambient.

F. UL Listed & Labeled K-Rating: K-7 or higher.

G. Noise levels:
   1. Per NEMA ST-20
   2. Production Test every unit. Data to be available upon request.
### H. Maximum No Load Losses:

<table>
<thead>
<tr>
<th>Transformer Rating</th>
<th>Maximum No Load Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kVA</td>
<td>60 W</td>
</tr>
<tr>
<td>30 kVA</td>
<td>99 W</td>
</tr>
<tr>
<td>45 kVA</td>
<td>130 W</td>
</tr>
<tr>
<td>75 kVA</td>
<td>180 W</td>
</tr>
<tr>
<td>112.5 kVA</td>
<td>260 W</td>
</tr>
<tr>
<td>150 kVA</td>
<td>330 W</td>
</tr>
<tr>
<td>225 kVA</td>
<td>450 W</td>
</tr>
<tr>
<td>300 kVA</td>
<td>560 W</td>
</tr>
<tr>
<td>500 kVA</td>
<td>850 W</td>
</tr>
<tr>
<td>750 kVA</td>
<td>1200 W</td>
</tr>
</tbody>
</table>

### I. Minimum efficiency at 1/6 loading:

<table>
<thead>
<tr>
<th>Transformer Rating</th>
<th>Minimum Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kVA</td>
<td>97.0%</td>
</tr>
<tr>
<td>30 kVA</td>
<td>97.6%</td>
</tr>
<tr>
<td>45 kVA</td>
<td>97.8%</td>
</tr>
<tr>
<td>75 kVA</td>
<td>98.3%</td>
</tr>
<tr>
<td>112.5 kVA</td>
<td>98.5%</td>
</tr>
<tr>
<td>150 kVA</td>
<td>98.4%</td>
</tr>
<tr>
<td>225 kVA</td>
<td>98.6%</td>
</tr>
<tr>
<td>300 kVA</td>
<td>98.7%</td>
</tr>
<tr>
<td>500 kVA</td>
<td>98.8%</td>
</tr>
<tr>
<td>750 kVA</td>
<td>98.9%</td>
</tr>
</tbody>
</table>

### J. Minimum efficiency per DOE 10 CFR Part 430 CSL 3 Efficiency requirement, tested per NEMA TP-2:

<table>
<thead>
<tr>
<th>Transformer Rating</th>
<th>Minimum Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kVA</td>
<td>97.6%</td>
</tr>
<tr>
<td>30 kVA</td>
<td>98.1%</td>
</tr>
<tr>
<td>45 kVA</td>
<td>98.3%</td>
</tr>
<tr>
<td>75 kVA</td>
<td>98.6%</td>
</tr>
<tr>
<td>112.5 kVA</td>
<td>98.8%</td>
</tr>
<tr>
<td>150 kVA</td>
<td>98.9%</td>
</tr>
<tr>
<td>225 kVA</td>
<td>98.9%</td>
</tr>
<tr>
<td>300 kVA</td>
<td>99.0%</td>
</tr>
<tr>
<td>500 kVA</td>
<td>99.1%</td>
</tr>
<tr>
<td>750 kVA</td>
<td>99.2%</td>
</tr>
</tbody>
</table>
K. Minimum efficiency under K-7 nonlinear load at 50% of nameplate rating:

<table>
<thead>
<tr>
<th>Transformer Rating</th>
<th>Minimum Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kVA</td>
<td>97.2%</td>
</tr>
<tr>
<td>30 kVA</td>
<td>97.7%</td>
</tr>
<tr>
<td>45 kVA</td>
<td>97.9%</td>
</tr>
<tr>
<td>75 kVA</td>
<td>98.1%</td>
</tr>
<tr>
<td>112.5 kVA</td>
<td>98.5%</td>
</tr>
<tr>
<td>150 kVA</td>
<td>98.7%</td>
</tr>
<tr>
<td>225 kVA</td>
<td>98.8%</td>
</tr>
<tr>
<td>300 kVA</td>
<td>98.8%</td>
</tr>
<tr>
<td>500 kVA</td>
<td>98.9%</td>
</tr>
<tr>
<td>750 kVA</td>
<td>99.1%</td>
</tr>
</tbody>
</table>

L. Voltage Taps: For transformers 30kVA-300kVA, provide two 2-1/2% full capacity taps above and below nominal primary voltage. For transformers 15kVA as well as 500kVA and larger provide one 5% full capacity tap above and below nominal primary voltage.

M. Impedance: Between 3.5% and 5.8% unless otherwise noted.

N. Enclosure type: Ventilated NEMA 2, drip-proof. NEMA 3R for outdoor

O. Shield each winding independently with a single full-width copper electrostatic shield.

P. Supply lug kit with standard screw-type lugs.

Q. Provide twin-lockable hinged doors for ease of access, maintenance and infrared testing.

R. Infrared Viewing Port Option: (Front Panel) Two sizes available for ease of Infrared testing.

S. Maximum sound levels shall be warranted as follows:
1. 15, 30, 45 KVA: 45dB
2. 75, 112.5, 150 KVA: 50 dB
3. 225, 300 KVA: 55dB
4. 500 KVA: 60dB
5. 750 kVA: 64dB

T. Factory Finish:
1. All non-painted steel parts shall be zinc plated.
2. All painted steel parts shall be cleaned and a zinc- phosphate (outdoor equipment) or iron phosphate (indoor equipment) pre-treatment applied prior to paint application.
3. Paint shall be Tiger Drylac: RAL 6018 rough texture, glossy, polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be minimum 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.
4. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.3-1987. Salt spray withstand tests in accordance with paragraph 5.2.8.4 shall be per-
formed on a periodic basis to provide conformance to this corrosion resistance standard of at least 2500 hours minimum (outdoor equipment) or 600 hours minimum (indoor equipment).

U. Acceptable manufacturer: Powersmiths International Corp eSaver-C3L Series, or approved equal.

2.06 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26.05.53 "Identification for Electrical Systems."

2.07 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
   1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
   2. Ratio tests at rated voltage connections and at all tap connections.
   3. Phase relation and polarity tests at rated voltage connections.
   4. No load losses, and excitation current and rated voltage at rated voltage connections.
   5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
   6. Applied and induced tensile tests.
   7. Regulation and efficiency at rated load and voltage.
   8. Insulation-Resistance Tests:
      a. High-voltage to ground.
      b. Low-voltage to ground.
      c. High-voltage to low-voltage.
   9. Temperature tests.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26.05.26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
   2. Brace wall-mounted transformers as specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."
   1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.03 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.04 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
   1. Visual and Mechanical Inspection.
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, and grounding.
      c. Verify that resilient mounts are free and that any shipping brackets have been removed.
      d. Verify the unit is clean.
      e. Perform specific inspections and mechanical tests recommended by manufacturer.
      f. Verify that as-left tap connections are as specified.
      g. Verify the presence of surge arresters and that their ratings are as specified.
   2. Electrical Tests:
      a. Measure resistance at each winding, tap, and bolted connection.
      b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
      c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
      d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
   1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
   3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION
SECTION 26 24 13
SWITCHBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.03 RELATED SECTIONS
A. Section 26 05 74 "Overcurrent Protective Device Arc-Flash Study" for arc-flash study and arc-flash label requirements.

1.04 ACTION SUBMITTALS
A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
1. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
5. Detail utility company’s metering provisions with indication of approval by utility company.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
8. Include schematic and wiring diagrams for power, signal, and control wiring.
C. Delegated Design Submittal:
   1. For arc-flash hazard study.
   2. For arc-flash labels.
   3. Seismic and anchorage design.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. Include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
      c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
   2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
   4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.10 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

C. Unusual Service Conditions: NEMA PB 2, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by City or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than seven calendar days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without City’s written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of panelboard, switchgear, transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.12 WARRANTY

A. Requirements:
1. Guarantee shall be in accordance with Part IV: General Conditions, Section B: Scope of Work.
2. Warranty period starts from “Date of Acceptance” by City.
3. Warranty period of number years covering materials and manufacturing defects.
   Warranty Period: Three years from date of Project Acceptance.
4. Provide a copy of manufacturer’s written warranty statement.

B. Manufacturer’s Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

C. Manufacturer’s Warranty: Manufacturer’s agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Project Acceptance.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.
   5. IEM
   6. Or approved equal.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

H. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Panel mounted.
   3. Sections front and rear aligned.

I. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 26.05.48.16 "Seismic Controls for Electrical Systems."
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

J. Indoor Enclosures: Steel, NEMA 250, Type 1.

K. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
L. Outdoor Enclosures: Type 3R.
   1. Finish: Factory-applied finish in manufacturer's standard color; undersurfaces
treated with corrosion-resistant undercoating.
   2. Enclosure: Downward, rearward sloping roof; rear hinged doors for each section,
with provisions for padlocking.
   3. Power for space heaters, ventilation, lighting, and receptacle provided by a re-
   mote source.

M. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each
vertical section to maintain enclosure temperature above expected dew point.
   1. Space-Heater Control: Thermostats to maintain temperature of each section
above expected dew point.

N. Service Entrance Rating: Switchboards intended for use as service entrance equip-
ment shall contain from one to six service disconnecting means with overcurrent pro-
tection, a neutral bus with disconnecting link, a grounding electrode conductor termi-
nal, and a main bonding jumper.

O. Customer Metering Compartment: A separate customer metering compartment and
section with front hinged door, and section with front hinged door, for indicated meter-
ing, and current transformers for each meter. Current transformer secondary wiring
shall be terminated on shorting-type terminal blocks. Include potential transformers
having primary and secondary fuses with disconnecting means and secondary wiring
terminated on terminal blocks.

P. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switch-
board.

Q. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts,
for access to rear interior of switchboard.

R. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank
compartments.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.
   1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left
to right when viewed from the front of the switchboard.
   2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity,
   silver-plated.
   3. Copper feeder circuit-breaker line connections.
   4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same ma-
terial as through buses, equipped with compression connectors for outgoing cir-
cuit conductors. Provide load terminals for future circuit-breaker positions at full-
ampere rating of circuit-breaker position.
   5. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equi-
   pped with compression connectors for feeder and branch-circuit ground con-
ductors.
   6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire
length of switchboard's main and distribution sections. Provide for future exten-
sions from both ends.
7. Disconnect Links:
   a. Isolate neutral bus from incoming neutral conductors.
   b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.03 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.
   5. IEM
   6. Or approved equal.

B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2.

C. Features and Accessories:
   1. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   2. Indicator light display for protection status.
   3. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   4. Surge counter.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
   1. Line to Neutral: 1200 V for 480Y/277 V; 700 V for 208Y/120 V
   2. Line to Ground: 1200 V for 480Y/277 V; 1200 V for 208Y/120 V
   3. Line to Line: 2000 V for 480Y/277 V; 1000 V for 208Y/120 V

F. SCCR: Approved equal or exceed 100 kA.

G. Nominal Rating: 20 kA.
2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long and short time adjustments.
      d. Ground-fault pickup level, time delay, and I squared t response.
   5. MCCB Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
      c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
      d. Ground-Fault Protection: Integrimally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
      f. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 09 13 "Electrical Power Monitoring and Control."
      g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
      h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
      i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
      j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

C. Fuses are specified in Section 26 28 13 "Fuses."
2.05 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:
   1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; discon-
      necting type with integral fuse mountings. Burden and accuracy shall be con-
      sistent with connected metering and relay devices.
   2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single
      secondary winding and secondary shorting device. Burden and accuracy shall be
      consistent with connected metering and relay devices.
   3. Control-Power Transformers: Dry type, mounted in separate compartments for
      units larger than 3 kVA.
      secondary wiring to ground overcurrent relays, via shorting terminals, to provide
      selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-
      breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or
   four-wire systems and with the following features:
   1. Switch-selectable digital display of the following values with maximum accuracy
      tolerances as indicated:
      a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
      b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
      c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
      d. Megawatts: Plus or minus 1 percent.
      e. Megavars: Plus or minus 1 percent.
      f. Power Factor: Plus or minus 1 percent.
      g. Frequency: Plus or minus 0.1 percent.
      h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumu-
         lated values unaffected by power outages up to 72 hours.
      i. Megawatt Demand: Plus or minus 1 percent; demand interval programma-
         ble from five to 60 minutes.
      j. Contact devices to operate remote impulse-totalizing demand meter.
   2. Mounting: Display and control unit flush or semiflush mounted in instrument
      compartment door.

2.06 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from
   control-power transformer.

2.07 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protec-
   tive device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing
   from switchboard. Include relay and meter test plugs suitable for testing switchboard
   meters and switchboard class relays.

D. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 26 05 48.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.08 IDENTIFICATION

A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.

B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
   1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
   2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
   3. Protect from moisture, dust, dirt, and debris during storage and installation.
   4. Install temporary heating during storage per manufacturer’s instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified.
   1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, surge protection devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Install spare-fuse cabinet.

I. Comply with NECA 1.

3.03 CONNECTIONS

A. Comply with requirements for terminating cable trays specified in the drawings. Drawings indicate general arrangement of cable trays, fittings, and specialties.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

C. Support and secure conductors within the switchboard according to NFPA 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.04 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Acceptance Testing:
      a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
      b. Test continuity of each circuit.
   2. Test ground-fault protection of equipment for service equipment per NFPA 70.
   4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   5. Perform the following infrared scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 calendar days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Switchboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

3.07 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train City maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION
SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.
   3. Electronic-grade panelboards.

1.03 DEFINITIONS
A. ATS: Acceptance testing specification.
B. GFCI: Ground-fault circuit interrupter.
C. GFEP: Ground-fault equipment protection.
D. HID: High-intensity discharge.
E. MCCB: Molded-case circuit breaker.
F. SPD: Surge protective device.
G. VPR: Voltage protection rating.

1.04 ACTION SUBMITTALS
A. Product Data: For each type of panelboard.
   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

C. Delegated Design Submittal:
1. For arc-flash hazard study.
2. For arc-flash labels.
3. Seismic and anchorage design.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.
B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
C. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. Include the following:
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
1.08 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
      b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by City or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than two calendar days in advance of proposed interruption of electric service.
   2. Do not proceed with interruption of electric service without City’s written permission.
   3. Comply with NFPA 70E.

1.11 WARRANTY

A. Requirements:
   1. Guarantee shall be in accordance with Part IV: General Conditions, Section B: Scope of Work.
   2. Warranty period starts from “Date of Acceptance” by City.
   3. Warranty period number of years covering materials and manufacturing defects.
   4. Panelboard Warranty Period: 18 months from date of Project Acceptance
   5. Provide a copy of manufacturer's written warranty statement.

B. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
C. Special Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.01 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Flush and Surface-mounted, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Height: 90 inches to top of trim maximum.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   4. Skirt for Surface-Mounted Panelboards: Same gauge and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gauge and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer’s standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      b. Back Boxes: Same finish as panels and trim.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:
   1. Location: Convertible between top and bottom.
   2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
H. Phase, Neutral, and Ground Buses:
   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

J. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: 50 percent.
Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 110 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as calculated in Section 26 05 72 Overcurrent Protective Device Short-Circuit Study, but not less than 10,000 A rms symmetrical.

2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as calculated in Section 26 05 72 Overcurrent Protective Device Short-Circuit Study, but not less than 14,000 A rms symmetrical.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1 or Type 2.

2.03 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.


4. IEM

5. Or approved equal

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker.


F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.04 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.


4. Square D; by Schneider Electric.
5. IEM
6. Or approved equal

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on schedule.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.05 SPLIT BUS AND SEPARATED DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   4. Square D; by Schneider Electric.

B. Split bus panelboards shall be designed as multiple sections within a single enclosure. The electrical connection between sections shall be a single branch breaker in the upstream section wired to a single branch breaker or subfeed lugs in the receiving section. Configurations shall be one of the following and in accordance with the panel schedules:
   1. Up to 240VAC 3 phase:
      a. 20” wide
      b. 5.75” deep for NEMA 1
      c. 18 circuit main section & 30 circuit second section. Maximum 44” high with main lugs only or 56” high with main circuit breaker.
      d. 30 circuit main section & 18 circuit second section. Maximum 44” high with main lugs only or 56” high with main circuit breaker.
      e. 30 circuit main section & 30 circuit second section. Maximum 44” high with main lugs only or 56” high with main circuit breaker.
      f. 30 circuit main section, 18 circuit second section and 18 circuit third section. Maximum 50” high with main lugs only or 62” high with main circuit breaker.
2.06 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   4. Square D; by Schneider Electric.
   5. IEM
   6. Or approved equal.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents calculated in Section 26.05.72 Overcurrent Protective Device Short-Circuit Study.
   1. Thermal-Magnetic Circuit Breakers:
      a. Inverse time-current element for low-level overloads.
      b. Instantaneous magnetic trip element for short circuits.
      c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   3. Electronic Trip Circuit Breakers:
      a. RMS sensing.
      b. Field-replaceable rating plug or electronic trip.
      c. Digital display of settings, trip targets, and indicated metering displays.
      d. Multi-button keypad to access programmable functions and monitored data.
      e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
      f. Integral test jack for connection to portable test set or laptop computer.
      g. Field-Adjustable Settings:
         1) Instantaneous trip.
         2) Long- and short-time pickup levels.
         3) Long and short time adjustments.
         4) Ground-fault pickup level, time delay, and I squared T response.
   4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
   5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
   8. MCCB Features and Accessories:
      a. Standard frame sizes, trip ratings, and number of poles.
      b. Breaker handle indicates tripped status.
      c. UL listed for reverse connection without restrictive line or load ratings.
      d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
      e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
      f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 26 09 13 "Electrical Power Monitoring and Control."

h. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.

k. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.

l. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.

m. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

n. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.

o. Multipole units enclosed in a single housing with a single handle.

p. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

q. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.07 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
   1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.08 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.
PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:
   1. Install panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in drawings.
   2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
   3. Comply with requirements for seismic control devices specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
J. Mount surface-mounted panelboards to steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.

K. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

M. Install filler plates in unused spaces.

N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

O. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

P. Mount spare fuse cabinet in accessible location.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate City final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 26 05 53 "Identification for Electrical Systems" identifying source of remote circuit.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   3. Perform the following infrared scan tests and inspections and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 calendar days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      c. Instruments and Equipment:
         1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

3.06 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION
SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
1. Controlled convenience receptacles.
2. Receptacles with USB Charging Ports.
3. Tamper-resistant receptacles.
4. GFCI receptacles.
5. Weather-resistant receptacles.
6. Twist-locking receptacles.
7. Solid-state fan speed controls.
8. Wall-switch and occupancy sensors.
10. Wall plates.
11. Floor service outlets and multioutlet assemblies.

1.03 DEFINITIONS

A. Abbreviations of Manufacturers’ Names:
1. Cooper: Cooper Wiring Devices; Division of Cooper Industries, Inc.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

H. UTP: Unshielded twisted pair.
1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Receptacles for City-Furnished Equipment. Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

1.05 ACTION SUBMITTALS

A. Samples: One for each type of device and wall plate specified, in each color specified.
B. Shop Drawings. List of legends and descriptions of materials and process used for premarking wall plates.
C. Samples: One for each type of device and wall plate specified, in each color specified.

1.06 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Floor service-outlet assemblies: one for every 10, but not fewer than one.

PART 2 - PRODUCTS

2.01 MANUFACTURES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
   2. Hubbell Incorporated; Wiring Device-Kellems.
   3. Leviton Manufacturing Co., Inc.
   5. Or approved equal.

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.02 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
   1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
   2. Devices shall comply with the requirements in this Section.

D. Devices for City-Furnished Equipment:
   1. Receptacles: Match plug configurations.
   2. Cord and Plug Sets: Match equipment requirements.

E. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.03 TWIST-LOCKING RECEPACTLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour/Legrand (Pass & Seymour).
      e. Or approved equal.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour/Legrand (Pass & Seymour).
   2. Description:
      a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
      b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.04 STRAIGHT-BLADE RECEPACTLES WITH USB CHARGING PORTS

A. Duplex Convenience Receptacles: Square face, industrial grade, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596, with minimum qty 2 USB Charging Ports.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (Arrow Hart).
      b. Hubbell Incorporated; Wiring Device-Kellems.
      c. Leviton Manufacturing Co., Inc.
d.  Pass & Seymour/Legrand (Pass & Seymour).
e.  Or approved equal.

2.05  GFCI RECEPTACLES

A.  General Description:
   1.  Square face, industrial grade, 125 V, 20 A, straight blade, non-feed-through type.
   2.  Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 943 Class A, and FS W-C-596.
   3.  Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B.  Duplex GFCI Convenience Receptacles:
   1.  Manufacturers: Subject to compliance with requirements, provide products by one of the following:
       a.  Cooper Wiring Devices Inc: Division of Cooper Industries, Inc.
       b.  Hubbell Incorporated; Wiring Device-Kellems.
       c.  Leviton Manufacturing Co., Inc.
       d.  Pass & Seymour/Legrand (Pass & Seymour).
       e.  Or approved equal.

2.06  DECORATIVE-STYLE DEVICES

A.  Convenience Receptacles: Square face, 125 V, 15 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-15R, and UL 498.
   1.  Manufacturers: Subject to compliance with requirements, provide products by one of the following:
       a.  Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
       b.  Hubbell Incorporated; Wiring Device-Kellems.
       c.  Leviton Manufacturing Co., Inc.
       d.  Pass & Seymour/Legrand (Pass & Seymour).
   2.  Description: Labeled to comply with NFPA 70, "Receptacles, Cord Connectors, and Attachment Plugs (Caps)" Article, "Tamper-Resistant Receptacles in Dwell- ing Units” Section.

B.  Toggle Switches, Square Face, 120/277 V, 15 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
   1.  Manufacturers: Subject to compliance with requirements, provide products by one of the following:
       a.  Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
       b.  Hubbell Incorporated; Wiring Device-Kellems.
       c.  Leviton Manufacturing Co., Inc.
       d.  Pass & Seymour/Legrand (Pass & Seymour).

C.  Controlled Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, UL 498 and Federal Specification W-C-596. Marking permanently printed, molded, or stamped on the face of the receptacle and in compliance with Controlled Receptacle Marking requirements stated in Article 406.3(E) of the 2014 National Electrical Code.
2.07 CORD REELS
1. Ceiling mount via unistrut frame. With pivot base capable of 330 degree rotation.
2. Cord shall be minimum 45 feet in length, #12/3, SJEO, black unless otherwise selected by architect.
3. Cord end with duplex receptacle outlet box and 20 ampere receptacle. See also duplex receptacle.
4. Manufacturer: Hubbell #HBL45123R20 or equivalent from Cooper, Arlington, Pass & Seymour, Leviton or approved equal

2.08 PENDANT CORD-CONNECTOR DEVICES
A. Description:
   1. Matching, locking-type plug and receptacle body connector.
   2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
   4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.09 CORD AND PLUG SETS
A. Description:
   1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.

2.10 FINISHES
A. Device Color connected to normal power system:
   1. Finished Spaces: White.
   2. Kitchen Areas and Bathrooms: Gray.
   3. Unfinished Spaces: Gray.
   4. Wet-Locations (concealed with weatherproof cover plate; see wall plates): Gray.
   5. Surface Raceways and Floor Boxes: Gray.
   6. Final finishes as selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

B. Wiring devices connected to emergency power system: Red.

C. Match device color so that gray devices have stainless steel plates and white devices have white plates.
2.11 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
   2. Material for Finished Spaces: 0.035-inch thick, satin-finished, Type 302 stainless steel.
   4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

C. Match wall plate color so that gray devices have stainless steel plates and white devices have white plates.

2.12 PREFABRICATED MULTIOU TLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Incorporated; Wiring Device-Kellems.
   2. Wiremold / Legrand AL4000.

B. Description:
   1. Kitchen areas: One-piece surface metal raceway, aluminum. Receptacles shall be oriented vertically so that screws are above and below receptacles. Do not orient receptacles horizontally (sideways) where screws are located at sides of receptacles.
   2. IT office: Two-piece surface metal raceway, with factory-wired multioutlet harness. One compartment for power. One compartment for telecommunications.
   3. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
   5. See plans for lengths and locations.

C. Raceway Material: Metal, with manufacturer's standard finish.

2.13 FLOOR SERVICE FITTINGS

A. Manufacturers: FSR Inc. FL-500P-3", 3-inch deep box.

B. KO trade sizes: 1"C concentric for power and 1-1/4"C concentric for telecommunications.

C. Type: Modular, flush-type, dual-service units suitable for wiring method used.

D. Compartments: Barrier separates power from voice and data communication cabling. Provide Plate Configuration 4 on one side for power. On the other side, provide Configuration 4 for telecommunications.
E. Service Cover Plate: Stainless steel cover with no flange and hinged door. FL-500P-SS-C.

F. Pour Pan. FL-GRD2.

G. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

H. Voice and Data Communication Outlet: Six modular, keyed, color-coded, RJ-45 jacks for UTP cable complying with requirements.

2.14 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hubbell Incorporated; Wiring Device-Kellems.
   2. Pass & Seymour/Legrand (Pass & Seymour).
   3. Square D; by Schneider Electric.
   4. Wiremold / Legrand.
   5. Or approved equal.

B. Description:
   1. Factory-fabricated and wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
   2. Comply with UL 514 scrub water exclusion requirements.
   3. Service-Outlet Assembly: Flush type with four simplex receptacles and space for four RJ-45 jacks complying with requirements.
   4. Size: Selected to fit nominal 8-inch cored holes in floor and matched to floor thickness.
   5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
   6. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
   7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables that comply with requirements.

2.15 FINISHES

A. Device Color:
   1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
   3. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
B. Coordination with Other Trades:
   1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:
   1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Existing Conductors:
      a. Cut back and pigtail, or replace all damaged conductors.
      b. Straighten conductors that remain and remove corrosion and foreign matter.
      c. Pigtailling existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:
   1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.
   9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and re-mount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.02 GFCI RECEPTACLES
A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.03 IDENTIFICATION
A. Comply with Section 26 05 53 "Identification for Electrical Systems."
B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.04 FIELD QUALITY CONTROL
A. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Perform the following tests and inspections:
1. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Tests for Convenience Receptacles:
1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mount-
ed.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devic-es, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
D. Wiring device shall be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION
SECTION 26 28 13

FUZZES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Control circuits.
      b. Panelboards.
      c. Switchboards.
      d. Enclosed controllers.
      e. Enclosed switches.
   2. Spare-fuse cabinets.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
   5. Coordination charts and tables and related data.
   6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. Include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.

4. Coordination charts and tables and related data.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.06 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bussmann, an Eaton business.
   2. Edison; a brand of Bussmann by Eaton.
   3. Littelfuse, Inc.
   4. Mersen USA.
   5. Or approved equal.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
   1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
   2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
   3. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.
E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.03 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
   1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
   2. Finish: Gray, baked enamel.
   3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
   4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Motor Branch Circuits: Class RK1 Class RK5, time delay.
   2. Other Branch Circuits: Class RK1, time delay Class RK5, time delay.

3.03 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

3.04 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26.05.53 "Identification for Electrical Systems" and indicating fuse replacement in-
formation inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION
SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Receptacle switches.
   4. Shunt trip switches.
   5. Molded-case circuit breakers (MCCBs).
   7. Enclosures.

1.03 DEFINITIONS

A. NC: Normally closed.
B. NO: Normally open.
C. SPDT: Single pole, double throw.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).
   4. Include evidence of NRTL listing for series rating of installed devices.
   5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
   6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
   1. Wiring Diagrams: For power, signal, and control wiring.
1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
   1. Include the following:
      a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Fuse Pullers: Two for each size and type.

1.08 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.09 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
   2. Altitude: Not exceeding 6600 feet.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.02 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.03 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB Inc.
   2. Eaton.
   5. Square D; by Schneider Electric.
   6. Or approved equal.

B. Type HD, Heavy Duty:
   1. Single throw.
   2. Three pole.
   3. 600-V ac.
   4. 1200 A and smaller.
   5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
   6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
   2. Hookstick Handle: Allows use of a hookstick to operate the handle.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.
   4. Service-Rated Switches: Labeled for use as service equipment.
2.04 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.
   5. Or approved equal.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:
   1. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
   2. Hookstick Handle: Allows use of a hookstick to operate the handle.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.
   4. Service-Rated Switches: Labeled for use as service equipment.

2.05 SHUNT TRIP SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bussmann, an Eaton business.
   2. Littelfuse, Inc.
   3. Mersen USA.
   4. Or approved equal.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Nonfusable Switch: 600-V ac, amperage as indicated on construction documents. 30 Amp minimum; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power source of enough capacity to operate shunt trip, pilot, indicating and control devices.

E. Accessories:
   1. Oiltight key switch for key-to-test function.
   2. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
3. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 240-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.06 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. General Electric Company.
   4. Square D; by Schneider Electric.
   5. Or approved equal

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated Series rating is not allowed.

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.


I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.

J. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

K. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

L. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
   3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
   4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   7. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.
   8. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   10. Accessory Control Power Voltage: Integrally mounted, self-powered; 240-V ac.

2.07 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12), copper-free cast aluminum alloy (NEMA 250 Types 7, 9).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The
cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.02 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by City or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Construction Manager no fewer than seven calendar days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service.
   3. Do not proceed with interruption of electric service without City's written permission.
   4. Comply with NFPA 70E.

3.03 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
   1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   2. Outdoor Locations: NEMA 250, Type 3R
   4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
3.04 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

3.05 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.06 FIELD QUALITY CONTROL

A. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Verify that fuse sizes and types match the Specifications and Drawings.
      f. Verify that each fuse has adequate mechanical support and contact integrity.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
   a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
   e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:
   1. Visual and Mechanical Inspection:
      a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and clearances.
      d. Verify that the unit is clean.
      e. Operate the circuit breaker to ensure smooth operation.
      f. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.

e. Determine the following by primary current injection:

   1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

   2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

   3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

   4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Perform the following infrared scan tests and inspections and prepare reports:
   a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 calendar days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
   b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
   c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.
   1. Test procedures used.
   2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
   3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.07 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73 "Overcurrent Protective Device Coordination Study."

END OF SECTION
SECTION 26 43 13

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Requirements:
   1. Section 26 24 13 “Switchboards” for factory-installed SPDs.
   2. Section 26 24 16 “Panelboards” for factory-installed SPDs.

1.03 DEFINITIONS

A. Inominal: Nominal discharge current.

B. MCOV: Maximum continuous operating voltage.

C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

E. OCPD: Overcurrent protective device.

F. SCCR: Short-circuit current rating.

G. SPD: Surge protective device.

H. VPR: Voltage protection rating.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
COORDINATION
A. Provide ¼” scale drawing demonstrating that installation has been coordinated with work of other trades. Use actual dimensions from approved equipment submittals to coordinate layout and installation of SPD with panelboard, switchgear, transformers and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

INFORMATIONAL SUBMITTALS
A. Field quality-control reports.
B. Sample Warranty: For manufacturer’s special warranty.

CLOSEOUT SUBMITTALS
A. Maintenance Data: For SPDs to include in maintenance manuals.

WARRANTY
A. Manufacturer’s Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

GENERAL SPD REQUIREMENTS
A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
B. Comply with NFPA 70.
C. Comply with UL 1449.
D. MCOV of the SPD shall be the nominal system voltage.

SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB USA.
3. Current Technology Inc.
4. Eaton.
5. General Electric Company.
6. Intermatic, Inc.
7. Leviton Manufacturing Co., Inc.
8. Schneider Electric USA, Inc.
B. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1 and Type 2
1. SPDs with the following features and accessories:
   a. Integral disconnect switch.
   b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
   c. Indicator light display for protection status.
   d. Form-C contacts rated at 5 A and 250-VAC, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   e. Surge counter.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V, 1200 V for 208Y/120 V.
3. Line to Line: 2000 V for 480Y/277 V, 1000 V for 208Y/120 V.

E. SCCR: Equal or exceed 200 kA.

F. Nominal Rating: 20 kA.

2.03 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB USA.
3. Current Technology Inc.
4. Eaton.
5. General Electric Company.
6. Intermatic, Inc.
7. Leviton Manufacturing Co., Inc.
8. Liebert; a brand of Emerson Electric Co.
9. Schneider Electric USA, Inc.
11. Square D; by Schneider Electric.
12. SSI, an ILSCO Company.

B. SPDs: Comply with UL 1449, Type 2.
1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-VAC, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
2. Line to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
3. Neutral to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.

E. SCCR: Equal or exceed 100 kA.

F. Nominal Rating: 10 kA.

2.04 ENCLOSURES
A. Indoor Enclosures: NEMA 250, Type 1.
B. Outdoor Enclosures: NEMA 250, Type 3R.

2.05 CONDUCTORS AND CABLES
A. Power Wiring: Same size as SPD leads, complying with Section 26 05 19 “Low-Voltage Electrical Power Conductors and Cables.”

PART 3 - EXECUTION
3.01 INSTALLATION
A. Comply with NECA 1.
B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer’s recommended lead length. Do not bond neutral and ground.
D. Use crimped connectors and splices only. Wire nuts are unacceptable.
E. Wiring:
2. Controls: Comply with wiring methods in Section 26 05 19 “Low-Voltage Electrical Power Conductors and Cables.”

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
   1. Compare equipment nameplate data for compliance with Drawings and Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer’s written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.03 STARTUP SERVICE

A. Complete startup checks according to manufacturer’s written instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests and reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to operate and maintain SPDs.

END OF SECTION
SECTION 26 51 19
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
A. Section includes the following types of LED luminaires:
   1. Materials.
   2. Finishes.
   3. Luminaire support.
B. Related Requirements:
   1. Section 26 09 43 "Distributed Lighting Control System"

1.03 DEFINITIONS
A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS
A. Product Data: For each type of product.
   1. Arrange in order of luminaire designation.
   2. Include data on features, accessories, and finishes.
   3. Include physical description and dimensions of luminaires.
   4. Include emergency lighting units, including batteries and chargers.
   5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
   6. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-80.
a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.
   1. Include plans, elevations, sections, and mounting and attachment details.
   2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:
   1. Product Data: Indicating luminaire is certified by ENERGY STAR and/or Design Lights Consortium, where applicable.

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

E. Samples for Initial Selection: For each type of luminaire with custom factory-applied finishes.
   1. Include Samples of luminaires and accessories involving color and finish selection.

F. Samples for Verification: For each type of luminaire.
   1. Include Samples of luminaires and accessories to verify finish selection.

G. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
1.06 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' model.

1.07 MAINTENANCE MATERIAL SUBMITTALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE
A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

D. Mockups: For interior luminaires in room or module mockups, complete with power and control connections.
   1. Obtain Architect's approval of luminaires in mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING
A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY
A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within five-year Warranty Period.
B. Warranty Period: Five year(s) from date of Project acceptance, or as specified per luminaire schedule, covering materials and manufacturing defects.

C. Guarantee shall be in accordance with Part IV: General Conditions, Section B: Scope of Work.

D. Warranty period starts from “Date of Acceptance” by City.

E. Provide a copy of manufacturer’s written warranty statement.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
   1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.02 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Standards:
   1. ENERGY STAR certified.
   2. California Title 24 compliant.
   3. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
   4. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
   5. UL Listing: Listed for damp location.
   6. Recessed luminaires shall comply with NEMA LE 4.
   7. User Replaceable Lamps:
      a. Bulb shape complying with ANSI C78.79.
      b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

C. Lamps dimmable from 100 percent to 0 percent of maximum light output.

D. Internal driver.

2.03 MATERIALS

A. Metal Parts:
   1. Free of burrs and sharp corners and edges.
   2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:
   1. As specified per luminaire schedule.

D. Housings:
   1. As specified per luminaire schedule.

E. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   1. Label shall include the following lamp characteristics:
      a. "USE ONLY" and include specific lamp type.
      b. Lamp diameter, shape, size, wattage, and coating.
      c. CCT and CRI for all luminaires.

2.04 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.05 LUMINAIRE SUPPORT

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.


D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Provide support for luminaire without causing deflection of ceiling or wall.
   4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:
   1. Secured to outlet box.
   2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls, or Attached to a minimum 20 gauge backing plate attached to wall structural members.
   2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Mounted Luminaire Support:
   1. Ceiling mount with two 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length or as specified per luminaire schedule.
   2. Ceiling mount with pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 120 inches in length or as specified per luminaire schedule.
   3. Ceiling mount with hook mount.

H. Suspended Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing, rod, or wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:
   1. Secure to any required outlet box.
   2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
   3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

J. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.04 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL
A. Perform the following tests and inspections:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire shall be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.06 STARTUP SERVICE
A. Comply with requirements for startup specified in Section 26 09 43.02 "Distributed Lighting Control System."

3.07 ADJUSTING
A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
   1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
   2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION
SECTION 26 56 19
LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY
   A. Section Includes:
      1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
      2. Luminaire supports.
      3. Luminaire-mounted photoelectric relays.
   B. Related Requirements:
      1. Section 26 09 43 "Distributed Lighting Control System" for lighting control system.

1.03 DEFINITIONS
   A. CCT: Correlated color temperature.
   B. CRI: Color rendering index.
   C. Fixture: See "Luminaire."
   D. IP: International Protection or Ingress Protection Rating.
   E. Lumen: Measured output of lamp and luminaire, or both.
   F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS
   A. Product Data: For each type of luminaire.
      1. Arrange in order of luminaire designation.
      2. Include data on features, accessories, and finishes.
      3. Include physical description and dimensions of luminaire.
      4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
      5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

6. Wiring diagrams for power, control, and signal wiring.
7. Photoelectric relays.
8. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:
1. Product Data: BUG ratings.
2. Product Data: Luminaire calculations.
3. Product Data: Indicating luminaire is certified by ENERGY STAR and/or Design Lights Consortium, if applicable.

D. Samples: For each luminaire and for each color and texture indicated with factory-applied finish.

E. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

F. Delegated-Design Submittal: For luminaire supports.
1. Include design calculations for luminaire supports and seismic restraints.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing laboratory providing photometric data for luminaires.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Product Certificates: For each type of the following:
1. Luminaire.
2. Photoelectric relay.
3. Factory installed lighting control devices.
D. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Source quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
   1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
   2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
   3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
   4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

F. Mockups: For exterior luminaires, complete with power and control connections.
   1. Obtain Architect's approval of luminaires in mockups before starting installations.
   2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.
3. Approval of mockups does not constitute approval of deviations from the Con- 
tract Documents contained in mockups unless Architect specifically approves 
such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part 
of the completed Work if undisturbed at time of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective 
covering prior to shipping.

1.10 FIELD CONDITIONS

A. Verify existing and proposed utility structures prior to the start of work associated with 
luminaire installation.

B. Mark locations of exterior luminaires for approval by Architect prior to the start of lumi-
naire installation.

1.11 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of lumi-
naires that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Structural failures, including luminaire support components.
   b. Faulty operation of luminaires and accessories.
   c. Deterioration of metals, metal finishes, and other materials beyond normal 
      weathering.
2. Warranty Period: 2 year(s) from date of Project Acceptance.
3. Guarantee shall be in accordance with Part IV: General Conditions, Section B: 
   Scope of Work.
4. Warranty period starts from “Date of Acceptance” by City.
5. Provide a copy of manufacturer’s written warranty statement for City’s review and 
   concurrence.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions 
determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock re-
sistant.
1. The term "withstand" means "the luminaire will remain in place without separation 
of any parts when subjected to the seismic forces specified and the luminaire will 
be fully operational during and after the seismic event."
2.02 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Bulb shape complying with ANSI C79.1.

G. Lamps dimmable from 100 percent to 0 percent of maximum light output.

H. Internal driver.

I. In-line Fusing: Separate in-line fuse for each luminaire.

J. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

K. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.03 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Cooper Lighting, an Eaton business.
   3. Deco Lighting.
   4. Eaton.
   5. GE Lighting Solutions.
   6. Intelligent Illuminations, Inc.
   7. Intermatic, Inc.
   8. Lithonia Lighting; Acuity Brands Lighting, Inc.
   10. Schneider Electric USA, Inc.
   11. Siemens Building Technologies, Inc.
   12. Or approved equal

B. Comply with UL 773 or UL 773A.

C. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second min-
imum time delay. Relay shall have directional lens in front of photocell to prevent arti-
1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.04 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: Corrosion-resistant aluminum or Stainless steel. Form and
support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage un-
der operating conditions, and designed to permit relamping without use of tools. De-
signed to prevent doors, frames, lenses, diffusers, and other components from falling
accidentally during relamping and when secured in operating position. Doors shall be
removable for cleaning or replacing lenses.

D. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indi-
cated:
1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

E. Housings:
1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or de-
form in use.
2. Provide filter/breather for enclosed luminaires.

F. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels
shall be located where they will be readily visible to service personnel, but not seen
from normal viewing angles when lamps are in place.
1. Label shall include the following lamp characteristics:
   a. "USE ONLY" and include specific lamp type.
   b. Lamp diameter, shape, size, wattage and coating.
   c. CCT and CRI for all luminaires.

2.05 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Vari-
tions in appearance of adjoining components are acceptable if they are within the
range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer’s standard paint applied to factory-assembled and
-tested luminaire before shipping. Where indicated, match finish process and color of
pole or support materials.
C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
   3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
   4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
      a. Color: As selected by Architect and Lighting Designer

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
   2. Exterior Surfaces: Manufacturer’s standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
      a. Color: As selected from manufacturer's standard catalog of colors.
      c. Color: As selected by Architect from manufacturer's full range.

2.06 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.

C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.
3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:
   1. Sized and rated for luminaire weight.
   2. Able to maintain luminaire position after cleaning and relamping.
   3. Support luminaires without causing deflection of finished surface.
   4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:
   1. Attached to structural members in walls, or Attached to a minimum 1/8 inch backing plate attached to wall structural members, or Attached using through bolts and backing plates on either side of wall.


H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photocell device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 26 05 33 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.04 BOLLARD LUMINAIRE INSTALLATION:

A. Align units for optimum directional alignment of light distribution.
   1. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bol-
laid base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.05 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 30 00 "Cast-in-Place Concrete."

3.06 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.07 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.08 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
   2. Verify operation of photoelectric controls.

C. Illumination Tests:
   1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
      a. IES LM-5.
      b. IES LM-50.
      c. IES LM-52.
      d. IES LM-64.
      e. IES LM-72.
   2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.
E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.09 DEMONSTRATION

A. Train City maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION
SECTION 27 00 00

COMMUNICATIONS

PART 1 - GENERAL

1.01 RELATED WORK

A. Summary

1. The objective of this and related specification documents is to define a universal and structured communications cable plant infrastructure for use with on this project. The goal of such a cable plant is to accommodate all current and anticipated voice and data systems with little or no modification, thus reducing administration and maintenance demand for resources.

2. This document does not specify the communications equipment such as the network hubs, routers, telephone switch and servers. However, the interface between such equipment and the cable plant is defined herein.

3. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section and to all Division 27 Sections.

1.02 RELATED WORK

A. Section 27 11 00 – Communications Equipment Room Fittings

B. Contra Costa Community College CCCCCD Infrastructure Standard

1.03 REFERENCES & STANDARDS

A. The design, cable and component selection, and installation practices shall conform with the following:

1. TIA-568-C: Commercial Building Telecommunications Wiring Standard

2. TIA-569-C: Commercial Building Standard for Telecommunications Pathways and Spaces.


4. TIA -607-B: Commercial Building Grounding and Bonding Requirements for Telecommunications.


7. TIA-942: Telecommunications Infrastructure Standards for Data Centers

8. American National Standards Institute / ANSI X3T9.5 FDDI, ANSI X3T9.5 CDDI


10. Institute of Electrical and Electronic Engineers (IEEE) 802.3, 802.5, 802.11
11. National Electrical Code Article 770 “Optical Fiber Cables” and Article 800 “Communications Circuits”
12. National Electrical Manufacturers Association (NEMA)
13. Local Electrical Code
15. NFPA 75 Protection of Electrical Computer/Data Processing Equipment
16. OSHA 29 CFR 1926/1910 Safety and Health Standards
17. Underwriters Laboratories, Inc. (UL) Listings and Approvals
18. UL 444 Communications Cables
19. Country, state and local health, safety and building codes

1.04 DEFINITIONS AND ABBREVIATIONS

A. The following definitions shall apply to this document and its companion sections for clarification and direction.

1. Owner: Contra Costa Community College District “CCCCCD”
2. Contractor: The Communications Contractor or sub-contractors responsible for installation, termination, test and documentation of communications cabling, termination components, pathway hardware, technology room hardware and related components, technology equipment room hardware and related components detailed in the technical descriptions for the scope of work pertaining to the Contra Costa Community College District Standards.
3. Communications Cable Plant: All communications cabling, wiring, termination hardware, racks, cabinets, labeling and all other associated hardware.
4. Communications Outlet: The device used to terminate station cables in couplers or connectors at user locations. It is the interface between the Station Cable and the end user’s equipment.
5. Horizontal (Station) Cabling: The portion of the communication link that connects the Communications Outlet to the TR. It is typically run horizontally on the same floor in a star topology emanating from the TR(s).
6. Outlet ID: A unique alpha-numeric identification used for referencing a communications outlet. The Outlet ID is a subset of the Cable ID. CCCCCD to authorize labeling schema prior to installation.
7. Cable ID: A unique alpha-numeric identification used for tagging the station cables, the jacks within a communications outlet and the termination blocks. CCCCCD to authorize labeling schema prior to installation.
8. 110-Block: References throughout this document to a 110-Block signify a 100-pair 11-block that is 4 rows high by 25-pair positions (i.e. 6 x 4-pair UTP cables) wide or a 300-pair 110-block that is 12 rows high by 25-pair positions (i.e. 6 x 4-pair UTP cables or 1 x 25-pair cable) wide regardless of manufacturer or mounting type, unless otherwise noted.
9. Station Field: 8-position, 8-conductor Modular (8P8C; “RJ-45”) termination panel used at the TR to distribute the station cables to the Station Outlets.
10. Backbone Cabling: The portion of the communication link that connects each TR with Technology Equipment Room. The Backbone cabling is typically run vertically in a star topology emanating from the Technology Equipment Room or Entrance Facility to all TRs. Backbone cabling consists of both copper and fiber cables.

11. Copper Backbone Field: RJ-45 style termination panel used to terminate backbone cabling in the Telecommunications Equipment Room or TR.

12. Fiber Backbone Field: Fiber Optic Patch Panels used to terminate backbone cabling in the Telecommunications Equipment Room or TR.

13. Data Equipment Field: The area in a 19" rack that contains the active equipment that makes up the local area network. This equipment could be made up of hubs, switches or other active hardware.

14. Technology Room (TR): A room that serves as the distribution point of station cabling to the surrounding area referred to as the TR Zone. The TR also houses all the terminations of station and backbone cabling as well as network, voice, security and other active equipment.

15. TR Zone: An area served by a Telecommunications Room. All Station Cabling from outlets in a TR Zone originate from that TR.

16. Technology Equipment Room (TER): The room where the telephone Company point-of-demarcation (DEMARC) is installed or originates from their public facilities. This is the service hand-off point or the point of origin for extending the DEMARC to other rooms within the building.

17. Permanent (Cable) Link: Includes the Communications Outlet, station cable and termination at the Technology Rooms and Technology Equipment Room.

18. Channel: Same as Basic Link, but also includes patch cords at the Communications Outlet and in the Technology Room.

19. Cross-Connect: Group of connection points, wall or rack mounted, used to mechanically terminate and administer building wiring.

1.05 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.

8P8C Eight Position, Eight Conductor modular Jack. Often referred to as an “RJ-45”.

AFF Above Finished Floor

ANSI American National Standard Institute

ATM Asynchronous Transfer Mode

AWG American Wire Gauge

BAS Building Automation System

BMS Building Management System

CDDI Fiber Distributed Data Interface over Copper
cm  centimeters
CM  Communications cable rated for general purpose use
CMP Communications cable rated for use in plenum areas
CMR Communications cable rated for use in risers and vertical runs
dB  Decibel
EF  Entrance Facility
EIDF Equipment Intermediate Distribution Facility
ELFEXT Equal-Level Far-End Cross Talk (pair-to-pair)
FCC Federal Communications Commission
FDDI Fiber Distributed Data Interface
ft.  feet
F/UTP Foiled Unshielded Twisted Pair
          No shielding around individual pairs and an overall foil shield under
          the cable jacket
HCP Horizontal Connection Point
IEEE Institute of Electrical and Electronic Engineers
in.  inch
kg.  kilogram
lbs. Pounds
LAN Local Area Network
m  meters
mm millimeters
Mbps Megabits per second
MDF Main Distribution Frame
MHz Mega Hertz (1E6 Hz)
µm Micrometer or micron (10E-6 meter)
N  Newton
NEXT Near End Cross Talk
OFNP Optical Fiber Nonconductive Plenum
OFNR Optical Fiber Nonconductive Riser
OTDR Optical Time Domain Reflectometer
PBX Private Branch Exchange (Telephone Switch)
pF  Pico Farad (10E-12 Farad)
1.06 WORK BY OWNER

A. Owner will:
   1. Furnish and install active electronics for interface with building voice and data cabling systems.
   2. Furnish and install connections from telephone and data equipment to Contractor provided cabling.
   3. Furnish and install patching and Cross Connections between Backbone and Horizontal Cabling.
   4. CCCCDD will provide the structured cabling system (SCS) guidelines for the preferred low voltage cabling contractor.

1.07 SUBMITTALS

A. Submit shop drawings for cabling and equipment provided under this Section:
   1. Note that for satisfying submittal requirements for Division 27, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 1. However, expression "Shop Drawings" is generally used throughout specification.

B. Refer to Division 1 for general guidelines on product or installation information to be submitted.

C. Mark general catalog sheets and drawings to indicate specific items submitted.

D. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.

E. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item for CCCCDD approval. Submittals shall be clearly marked and noted accordingly.

F. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
G. Submittals should be grouped to include complete documentation of related systems, products and accessories in a single submittal. Where applicable, dimensions shall be marked in units to match those specified.

H. Submittals shall be in electronic form (Adobe Acrobat PDF) or paper.
   1. Paper documents shall be original catalog sheets or photocopies thereof.
   2. Facsimile (fax) sheets shall not be accepted.

I. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.

1.08 QUALITY ASSURANCE

A. Certifications Requirements
   1. Each vendor shall have at least one BICSI RCDD or RITP on staff. The Contractor shall have the necessary certifications to provide for the Warranty as specified herein.
   2. The Contractor shall be an active participant in the Installers Program operated by the Manufacturer of the Cabling and/or Termination Components used. The Contractor shall be a participant in this program at the time of Bidding and remain so throughout the project.
   3. Upon request, the Certified Installer(s) assigned to the Project shall be identified to the Engineer.

1.09 APPROVED MANUFACTURERS
   1. Chatsworth Products Inc. (CPI) (Racks, Grounding)
   2. Commscope Systimax for Structured Cabling
   3. Legrand/Wiremold (Floor Boxes)
   4. Panduit (Grounding)

1.10 WARRANTY

A. This Article is applicable to all Division 27 Sections.

B. Refer to Division 1 General Provisions.

C. Unless specified otherwise in the technical sections which detail the requirements for each subsection, the Contractor shall warranty materials, equipment, etc. for a minimum of ten (10) years from date of substantial completion of work.
   1. This is inclusive of all Horizontal and Backbone Cabling and connecting components.
   2. Coverage shall include all labor, materials and travel time.
   3. Warranty on Structured Cabling System shall be direct from manufacturer(s) of cabling and connecting components to owner. (Commscope Systimax SCS)
PART 2 - EXECUTION

2.01 GENERAL

A. Refer to the individual technical specification sections for detailed Cable Routing and Installation, Testing and Documentation requirements. The following apply to all communications cabling and termination work.

2.02 CABLE ROUTING – GENERAL

A. Backbone cables should be routed separately from other building services so as to protect the cabling from unnecessary abuse. Separate conduit or a telecommunications riser shaft is recommended when it is deemed feasible.

2.03 CABLE INSTALLATION – GENERAL

A. The contractor shall furnish all required installation tools to facilitate cable pulling without damage to cable jacket.

B. All routing shall be kept clear of other trades work and supported using the method(s) detailed in the pertinent technical section(s).

C. During pulling operation an adequate number of workers shall be present to allow cable observation at all points of raceway entry and exit, as well as to feed cable and operate pulling machinery.

D. Pull cables in accordance with cable manufacturer's recommendations and ANSI/IEEE C2 Standards.

E. Pull all cable by hand unless installation conditions require mechanical assistance.
   1. Where mechanical assistance is used, ensure that maximum tensile load for cable installation is not exceeded. This may be in the form of continuous monitoring of pulling tension, use of "break-away" or other approved method.

F. All cables shall be installed splice-free unless otherwise specified and/or approved by the CCCCD.

G. Avoid abrasion and other damage to cables during installation.

H. Manufacturer specified pulling tensions shall not be exceeded.

I. Pulling lubricant may be used and shall:
   1. Be non-injurious to cable jacket and other materials used.
   2. Not harden or become adhesive with age.

J. Minimum bend radii, as specified by the manufacturer, must be adhered to for cable pulling and final installation.
   1. Any cables bent or kinked to radius less than recommended dimension are not allowed and shall be replaced at no expense to owner.
K. Repair damage to interior spaces caused by installation of cable, raceway or other hardware. Repairs must match preexisting color and finish of walls, floors and ceilings.

L. Replace contractor-damaged ceiling tiles to match color, size, style and texture.

M. Pull cord (200 lb minimum) shall be installed with cable installed in conduit or innerduct or Maxcell.

N. Cabling shall be neatly laced, dressed and supported to meet manufacturer’s requirements.

O. Provisions must be made to support the backbone cable passing vertically through the building. The cables should be supported on each floor using an industry approved support method of every 4’ vertically.

2.04 TESTING

A. Tests shall be conducted by the contractor during the course of construction when identifiable portion(s) of installation is complete. Alternatively, testing can be conducted after entire installation is complete if this does not delay the project schedule.

B. Prior to testing, the contractor shall submit a written description of the intended test procedures and submit sample test forms to the Engineer.
   1. The submitted information shall include the proposed file naming format to be used in identifying the cable, pair or optical fiber which is the subject of the test record.
   2. Failure to provide the above information shall be grounds for the Engineer or the owner to reject any and all Documentation of Results on related testing and to require a repeat of the affected test.

C. Prior to testing, the contractor shall submit to the owner (or owner’s representative) and the Engineer, a proposed schedule for acceptance testing. This notification shall be a minimum of five (5) working days in advance to allow for witnessing of the tests by a duly authorized representative of the owner.

D. The Contractor is responsible for supplying all equipment and personnel necessary to conduct the acceptance tests.

E. Testing shall be completed and accepted by the owner and Engineer before owner furnished equipment and cross connects are installed.

F. All tests shall be documented to be compliant to CCCCD requirements.

G. Test results shall be submitted within ten (10) working days of the completion of each testing phase (e.g. subsystem, cable type, area, floor, etc.) or no later than three (3) weeks prior to the scheduled occupancy of the subject area, whichever is earlier.
   1. Interim documentation of Test Results shall be submitted in original and raw electronic tester format on CD-ROM and USB jump drive for review and distribution.
H. Test results shall also be part of the Final Documentation package submitted by the Contractor on the project.

I. Fiber
   1. Test each strand of the fiber optic cables per Systimax guidelines to achieve manufacturer's warranty.
   2. Ensure that all strands meet the performance criteria for a 10G-BASE-S application.
   3. Apply the Systimax Fiber Optic Cable Testing procedures.

J. Copper Riser Cabling
   1. Test all copper pairs for continuity, polarity and shorts. Provide electronic test reports for each pair.

K. Copper Horizontal Cabling (SCS)
   1. Test all horizontal copper cabling per Systimax guidelines to achieve manufacturer's warranty.

2.05 DOCUMENTATION

A. Upon completion of the installation, the Contractor shall provide System Documentation to the Engineer for approval. Documentation shall include:
   1. Test Results: In manufacturer’s testing software raw native format, soft copies only.
   2. Record Drawings
   3. Copies of all approved submittals indicating products used in the installation.
   4. Phone numbers, physical addresses and Internet/webpage (URL) of local parts suppliers and service companies covering the products installed.

B. Submit four (4) copies of all required documentation.

C. Documentation of Test Results shall be submitted in electronic form on CD-ROM and USB Jump Drive for review and distribution.
   1. Test results shall be submitted in the original format(s) native to the test instrument(s) used in performing the testing.
   2. Where unique software (other than an MS Word - compatible Word Processor or MS-Excel spreadsheet) is required for viewing of the test results, the Contractor shall provide along with the above documentation, three (3) licensed copies of such software. The software shall run on a MICROSOFT Windows-based personal computer supplied by the owner.

D. Final Documentation shall be submitted to the CCCC, upon the CCCC’s request. This is inclusive of all Test Results and draft Record Drawings. Intent is to accommodate a large window of time for equipment deployment.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of all drawings shall be submitted within thirty (30) working days of the completion of each testing phase.
E. The Engineer or owner may request that a 10% random field re-test be conducted on the cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in the technical sections. If findings contradict the documentation submitted by the Contractor, additional testing can be requested to the extent determined necessary by the Engineer or owner, including a 100% re-test. This re-test shall be at no additional cost to owner.

F. All documentation - including hard copy and electronic forms of all Test Data and Record Drawings- shall become the property of owner.

END OF SECTION
SECTION 27 05 26

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Provide all labor, materials, and equipment for the complete installation of work called for in the Contract Documents.

B. This section includes the minimum requirements for the equipment and cable installations in telecommunications rooms, server rooms, and communications equipment rooms.

C. Included in this section are the minimum composition requirements and installation methods for the following:
   1. Busbars
   2. Bonding accessories

1.02 SUBMITTALS

A. Provide product data for the following:
   1. Manufacturer’s cut sheets, specifications and installation instructions for all products.

1.03 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the District or District Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufactures listed. Where “approved equal” is stated, equipment shall be equivalent in every way to that of the equipment specified and subject to approval.

B. Strictly adhere to all Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

C. Material and work specified herein shall comply with the applicable requirements of:
   1. TIA-568-C: Commercial Building Telecommunications Wiring Standard
   2. TIA-569-C: Commercial Building Standard for Telecommunications Pathways and Spaces
PART 2 - PRODUCTS

2.01 WALL-MOUNT BUSBARS

A. Telecommunications Main Grounding Busbar (TMGB)

B. Telecommunications Grounding Busbar (TGB)

C. Manufacturer
   1. Chatsworth Products Inc.
      a. TMGB: For use in TER at +90° AFF: Part Number: 40153-020
      b. TGB: For use in TR's at +90° AFF: Part Number 40153-012

2.02 BONDING ACCESSORIES

A. Two Mounting Hole Ground Terminal Block

B. Compression Lugs

C. Antioxidant Joint Compound

D. C-Type, Compression Taps

E. Pedestal Clamp with Grounding Connector

F. Pipe Clamp with Grounding Connector

G. Equipment Ground Jumper Kit

PART 3 - EXECUTION

3.01 INSTALLATION

A. Busbars (TMGB and TGB)
   1. Busbars shall be installed per District guidelines. Attach busbars to the wall in approved locations with appropriate hardware according to the manufacturer’s installation instructions. Mount at a height of +90°AFF.
   2. Conductor connections to the TMGB or TGB shall be made with two-hole bolt-on, double irreversible compression lugs sized to fit the busbar and the conductors.
   3. Each lug shall be attached with stainless steel hardware after preparing the bond according to manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.
   4. The wall-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.
   5. Connect the TMGB to the building main ground using minimum of a #4 or larger insulated copper wire per the electrical diagram riser.
   6. Connect the TGB to the TER TMGB with a minimum of a #6 or larger insulated copper wire and to the electrical panel serving the room per the electrical diagram riser.
7. Ground the cable runway to the TMGB using #6 or larger insulated copper wire. Abrade the finish on the cable runway where the ground wire is attached. Bond all cable runway junctions.

B. Busbars Outdoors
   1. Busbars shall be installed per District guidelines.

C. Ground Terminal Block
   1. Every rack and cabinet shall be bonded to the TMGB or TGB.
   2. Minimum bonding connection to racks and cabinets shall be made with a rack-mount two-hole ground terminal block sized to fit the conductor and rack and installed according to manufacturer recommendations. District requirements supersede.
   3. Remove paint between rack/cabinet and terminal block, clean surface and use antioxidant between the rack and the terminal block to help prevent corrosion at the bond. District requirements supersede.

D. Equipment Ground Jumper Kit
   1. Bond the equipment to a vertical rack-mount busbar or ground bar using ground jumper as per the manufacturer’s recommendations.
   2. Clean the surface and use antioxidant between the compression lugs on the jumper and the rack-mount busbar or ground bar to help prevent corrosion at the bond.

E. Labeling.
   1. Label each bonding and grounding conductor on both ends within 4” of terminations. All indoor labeling shall be machine generated, with adhesive to be placed on grounding conductors. All outdoor labeling shall be metal non corrosive tags stamped with identification markings approved by the District. Metal tags shall be designed for outdoor use.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY
   A. Section Includes: Telecommunications building pathways.

1.02 RELATED SECTIONS
   A. Division 26 – Basic Materials and Methods, Conduit, Boxes
   B. Section 27 15 13 – Telecommunications Horizontal Cabling
   C. Contra Costa Community College District Infrastructure Standard

1.03 REFERENCES
   A. Comply with the References requirements of Section 27 00 00.
   B. In addition to those codes, standards, etc., listed in Section 27 00 00, comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
      1. ASTM A 510 Specifications for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel
      3. ASTM A 653 Specifications for Steel Sheet, Zinc-Coated (Galvanized) by Hot Dip Process
      4. ASTM A 591 Specifications for Electrodepositing Coatings of Zinc on steel wire or sheets.
      5. ASTM A 123 Specifications for Zinc (Hot Galvanized) Coatings on Iron and Steel.

1.04 DEFINITIONS
   A. Definitions as described in Section 27 00 00 shall apply to this section.
   B. “Cable Hanger”: A metal, most often steel, cable support device shaped (section view) similar to the letter J; alternately, a fabric strap. The device is available in different sizes supporting different quantities of cables, and is also available with different attachment hardware to be supported by different methods (e.g., wire support, beam flange clip, etc.).
   C. Cable Runway or Ladder Rack: Overhead means to get cabling from point to point whether it be vertical or horizontal within Telecommunications Spaces such as TR’s and the TER.

1.05 SYSTEM DESCRIPTION
   A. Work Covered Under Other Sections
   B. Electrical Metallic Tubing (EMT) Conduit, pull boxes, device boxes – Refer to Division 26
The Telecommunications Building Pathways consist of the following subsystems:

A. Primary Pathways: Cable Hangers, including supports
   1. Secondary Pathways: Cable Hangers, including supports
   2. 4" Conduits between TER and TR’S; Between TR’s Shall be 4” sleeves; 4” Conduits where pathway is spanning drywall ceilings due to lack of accessibility for cabling placement.
   3. 3" Conduits where identified and required by code.
   4. 2" Conduits where identified and required by code.
   5. 1.5" Conduits where identified and required by code.
   6. 1" minimum conduits for all typical telecommunications work area outlets and where required by code.
   7. 4" conduits from the TER to contractor provided Utility Vault, part number 3672 (ATT Standard Vault) located on District Property adjacent to the SP maintenance hole for primary services. (Qty 6).
   8. 4" conduits from the TER to contractor provided Utility Vault, part number 3672 (ATT Standard Vault) located on District Property adjacent to the SP maintenance hole for secondary services. (Qty 4).

1.06 SUBMITTALS
A. General: Conform to Submittal requirements as described in Section 27 00 00.
B. Quantity: Furnish quantities of each submittal as noted in Section 27 00 00 and on drawings.
C. Submittal Requirements at Start of Construction:
   D. Product Data Submittal
   E. Shop Drawings Submittal: Consisting of proposed changes to pathway route plans.
   F. Submittal Requirements at Close Out:
   G. As-Built Drawings Submittal

1.07 SUBSTITUTIONS
A. Requests for substitutions shall conform to the requirements and procedure in Section 27 00 00.

1.08 QUALITY ASSURANCE
A. Comply with Quality Assurance requirements of Section 27 00 00.

1.09 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Comply with Delivery, Storage and Handling requirements of Section 27 00 00.

1.10 WARRANTY
A. Comply with Warranty requirements of Section 27 00 00.

PART 2 -PRODUCTS

2.01 OVERHEAD CABLE RUNWAY (LADDER RACK) IN TR’S AND TER
A. Application: Suitable for indoor installation to support, store, and manage telecommunications cables, either overhead or mounted vertically on a wall.

B. Provide all components of system (supports, splices, fasteners, and accessories) from manufacturer, Chatsworth Products, Inc.

C. When the pathway is overhead cable runway shall be installed with a minimum clearance of 12” (300 mm) above. Leave 12” (300 mm) in between the cable runway and ceiling/building truss structure. Multiple tiers of cable runway shall be installed with a minimum clearance of 12” (300 mm) in between cable runway. When located above an acoustical drop ceiling, shall be installed a minimum of 3” (75 mm) above the drop ceiling tiles.

D. Overhead cable runway shall be supported as specified by manufacturer and VEMA1 and VEMA-2. Support cable runway within 2’ (0.6 m) of every splice and intersection. Support intersections on all sides. Support cable runway on both sides of every change in elevation/direction. The weight of the load on the cable runway must not exceed the stated limits per span in the manufacturer’s published load table. Use additional supports where needed.

E. Secure cable runway to each support with a minimum of one fastener. Follow the manufacturers' recommended assembly, splice and intersection-forming practices.

F. Use installation tools and practices recommended by the manufacturer to field fabricate cable runway intersections and changes in elevation. Deburr all cut ends of cable runway to smooth finish with no rough edges and install protective end caps where exposed open ends are accessible.

G. All cable runway sections shall be bonded together. The electrical bonding of sections shall be bonded to the Telecommunications Grounding Busbars (TGB or TMGB) using a minimum #6 grounding wire or as recommended by the AHJ. Follow UL Classified splicing methods recommended by the manufacturer, ground the cable runway per NEC requirements and verify bonds at splices and intersections between individual cable runway sections. In the TER or TR, bond all cable runway together.

H. The quantity of cables installed on cable runway will not exceed a whole number value equal to 50% of the interior area of the tray divided by the cross-sectional area of the cable. Cable fill will not exceed the depth of the cable runway’s side rail retention posts [2” (50 mm), 4” (100 mm) or 6” (150 mm)].

I. Electrical Contractor shall install the cable runway in the TER. Support CPI cable runway with CPI part number 12362-718 center support kits with 5/8” threaded rods. Install the runway at +99” AFF to the bottom of the runway.

J. Electrical Contractor shall install the cable runway in the TR. Support CPI cable runway with CPI part number 12362-718 center support kits with 5/8” threaded rods. Install the runway at +99” AFF to the bottom of the runway.

K. The combined weight of cables within the runway will not exceed stated load capacity in manufacturer’s specifications.

L. Separate different media type within the cable runway. Treat each type of media separately when determining cable fill limits.

M. Materials, Finish and Manufacturer for each cable runway type pathway are as follows:
   1. Black in color
   2. Hardware shall be of the same manufacturer (Chatsworth Products, Inc.)
3. Refer to District Guidelines for sizes. (18")
4. Manufacturer: Chatsworth Products, Inc.
   a. TER: Part numbers:
      11275-718 for overhead
      11275-724 for walls
   b. TR's: Part Numbers:
      11275-718 for overhead
      11275-724 for walls

2.02 CABLE TRAYS
   A. Application: Suitable for indoor installation within ceiling space for the support of telecommunications cables.
   B. Listings: UL 2043, for use in air handling spaces
   C. Manufacturers
      1. Chatsworth Products, Inc.

2.03 THROUGH WALL PENETRATIONS
   A. Fire Rated walls and non-fire rated full height walls
      1. Contractor shall install a quantity of (4) EZDP44S EZ-Path’s at a minimum, for District use only.
   B. TR’S and TER walls: (for District use only)
      1. Contractor shall install EZ-Path assemblies
      2. EZDP44S with Radius Control Modules (RCM’s) on each end.
   C. Above cable runway and through walls, a quantity of (8) EZ-Path’s shall be installed at each entry and exit of each TR and TER. These are dedicated for District use only. Additional EZ-Path may be required for other systems.

2.04 DROP WIRE, PENCIL ROD AND ALL THREAD
   A. Application: Suitable for indoor installation within ceiling space into structure above (e.g., slab and/or deck) for the support of telecommunications support devices.
   B. Listings: UL 2043, for use in air handling spaces.
   C. Assembly shall be equipped with ceiling clip, pre-mounted fastening pin, plastic washer, and pre-tied wire.
   D. Fastening pin shall be 7/8".
   E. Pencil Rod and All Thread shall be a minimum of 1/4” diameter.
   F. Manufacturer, or equal:
      1. Hilti #CC27 X-AL-H22P8T xx ft PT; drop wire assembly, xx foot wire – where “xx” is the length

PART 3 EXECUTION

3.01 GENERAL
   A. Comply with the Execution requirements of Section 27 00 00.

3.02 EXAMINATION
A. Examine areas to receive overhead hanger/support system prior to the start of work within this section. Notify the General Contractor of conditions that would adversely affect the installation or subsequent utilization of the system. Do not proceed with installation until unsatisfactory conditions are corrected.

B. Installer is responsible for the integrity of the structures to which the system is attached, including their capability of safely accepting the loads imposed as evaluated by a qualified engineer.

3.03 INSTALLATION

Cable Hangers

A. Install hangers in accordance with recognized industry practices, to ensure that the installed system complies with requirements of the NEC, and applicable portions of NFPA 70B and NECA's “Standards of Installation” pertaining to general electrical installation practices.

B. Provide dedicated supports at sixty inches (60") separation, maximum, per a given route. Supports shall consist of ¼” threaded rod or pencil rod. Suspend wire or rod using components appropriate for the structure – e.g., powder-actuated clip fastener for wire, beam flange clip or angled flange clip for either wire or rod, or an embedded anchor for the threaded rod. Do not share support (wire/rod) with other trades. Do not support the hanger on ceiling grid support wires. Do not support the hanger from ductwork, piping, or other equipment hangers.

C. Install hangers six inches (6”), minimum, from light fixtures or other EMI source. Install hangers between six inches (6") and twelve inches (12") above ceiling grid.

D. Install system at locations indicated on the drawings. Routes are diagrammatic in nature. Field verify route prior to installation.

Cable Tray

A. Install cable tray and support systems according to NEMA VE 2.

B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Fasten cable tray supports to building structure[ and install seismic restraints] using manufacturer's recommended supports and appropriate hardware as defined by local code or the authority having jurisdiction.

F. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems."[ Comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."]

G. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

H. Support assembly to prevent twisting from eccentric loading.
I. Do not install more than one cable tray splice between supports.
J. Make changes in direction and elevation using manufacturer's recommended fittings.
K. Make cable tray connections using manufacturer's recommended fittings.
L. Install cable trays with enough workspace to permit access for installing cables.
M. Installation Tolerances:
   1. Overhead pathway: 12 inches (300 mm) minimum, above the tray.
   2. Ceiling or Building Truss: 12 inches (300 mm).
   3. Multiple tiers: Minimum clearance of 12 inches (300 mm) in between the trays.
   4. Acoustical ceilings: 3 inches (75 mm) minimum above the ceiling panels or tiles.
   5. Between trays and tray cross overs: 3 inch (75 mm) clearance.
N. Provide support for the following instances:
   1. Length of span: 6 feet (1.8 m) or less.
   2. Splices and Intersections.
   3. Change of direction or change of elevation.
   4. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.

3.04 Firestopping
A. Provide all services, labor, materials, tools, and equipment required for the complete and proper installation of firestopping for communications systems as called for in the specifications and related drawings.
B. Provide penetrations through fire-rated walls and partitions and firestopping of the penetrating items.
C. A through-penetration is created when a cable, conduit, or sleeve passes through an opening in a fire-rated wall or floor. The opening offers a path for fire and smoke to spread. A firestop is a special seal designed and tested to restore the fire integrity of the barrier.
D. Design requirements: Provide firestopping systems that are produced and installed to resist the spread of fire and the passage of smoke and other gases.
E. Deliver firestopping products to the project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying project and manufacturer; date of manufacture; lot number; shelf life, if applicable; qualified testing and inspecting agency's classification marking applicable to the project; curing time; and mixing instructions for multi-component materials.
F. When the firestop system has been installed, place a label next to the system.

END OF SECTION
SECTION 27 05 33

CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Back boxes and conduits for telecommunications work area outlets.

B. Related Documents:
   1. Section 26 05 33 – Raceways and Boxes for Electrical Systems
   2. Contra Costa Community College District Infrastructure Standard

1.02 REFERENCES

A. Codes: Work shall be performed in accordance with applicable requirements of governing codes, rules and regulations including the following minimum standards, whether statutory or not:
   1. National Building Code (NBC)
   2. National Electrical Code (NEC)
   3. National Fire Code (NFC)
   4. Canadian Standards Association (CSA)
   5. Electronic Industries Association (EIA)
   6. International Standards Organization (ISO)

B. Division 26 Specifications

C. Specification Information Requests: Direct requests for clarification, substitution, or changes in these specifications or drawings to the Architect.

1.03 SUBMITTALS

A. Product Data: For each product indicated.
   1. Obtain written approval from the Consultant for the product data submittal prior to materials and equipment purchase order and prior to installation.
   2. Format: Submit each product data as an electronic (PDF) document.
   3. Labeling: For each submittal, provide a cover page including the following information:
      a. Client Name
      b. Project Name and Address
      c. Submittal Name (e.g., “Product Data Submittal for LCD Panel Backbox.”)
      d. Specification Section Number (e.g., “Section 27 05 33”)
      e. Date of Submittal
      f. Contractor Name

B. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required. Use room designations indicated on Drawings.
PART 2 PRODUCTS

2.01 MANUFACTURERS

C. Subject to compliance with requirements, provide products by the following:
   1. Provide and install 5S Deep Back Box with single-gang mud ring for most Typical Telecommunications Work Area Outlets.
   2. Provide and install 5S Deep Back Box with double-gang mud ring for some Typical Telecommunications Work Area Outlets.

PART 3 EXECUTION

3.01 INSTALLATION

D. Complete work in a neat, high-quality manner, relative to common industry practices, and in accordance with the NFPA 70: National Electrical Code.

E. Complete work in conformance to applicable federal, municipal and local codes.

F. Coordinate the entire installation throughout the construction team, including the Owner’s audiovisual systems contractor.

G. All conduit shall be home-run or routed directly to the telecommunications room serving that area.

H. Certify device boxes are level when installed.

I. Install a minimum of a 1 1/4" conduit from all back boxes stubbed to accessible above ceiling spaces unless otherwise noted on construction drawings. Normally the conduit exits the wall facing the same side as the data outlet location.

J. Install conduits so as not to exceed 180 degrees of bend in any cabling run.

K. Where cabling runs require more than 180 degrees of bend, contact the District for approval and location prior to providing and installing any pull box.

L. Conduit purposed for floor box(es) must have the respective conduit turn up in an adjacent or nearby wall or column that is stubbed to nearest accessible ceiling. Conduit bends shall not exceed 180 degrees in all instances. Conduits shall be continuous from floor box locations to accessible ceiling.

M. Riser conduits or sleeves extending down from the ceiling shaft shall extend to 9 feet above finished floor.

N. Manufacturer’s Instructions:
   1. Comply with manufacturer’s product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.
   2. Maintain jobsite file of Material Safety Data Sheets (MSDS) for each product delivered to jobsite packaged with an MSDS.
3.02 FINAL INSPECTION AND CERTIFICATION

A. Punch Walks and Punch Lists
   1. Punching the Work of individual Sections of Division 27 may be combined.
   2. Execute a punch walk with the Consultant to observe work.
   3. Develop a punch list for items needing correction. Issue this punch list to Consultant.
   4. Correct the Work as noted on punch list.
   5. Execute follow up punch walk with the Engineer and the Owner or Owner's Representative to verify punch list items have been corrected.

END OF SECTION
SECTION 27 05 36
CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 and Division 27 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:
   1. Ladder cable trays.
   2. Wire-basket cable trays.

1.03 DEFINITIONS

A. See 270500, Common Work Results for Communications.

1.04 ACTION SUBMITTALS

A. Comply with submittal requirements in Section 270500, Common Work Results for Communications.

B. Product Data: For each type of cable tray.
   1. Include data indicating dimensions and finishes for each type of cable tray indicated.

C. Shop Drawings: For each type of cable tray.
   1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
   2. Vertical and horizontal offsets and transitions.
   3. Clearances for access above and to side of cable trays.
   4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays are to be installed in ceilings of hallways and corridors and avoid passing over occupied spaces such as classrooms, labs, studios and offices.

B. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
   1. Source Limitations: Obtain cable trays and components from single manufacturer.

2.02 LADDER CABLE TRAYS

A. Products: Subject to compliance with requirements, provide the following:
   1. Chatsworth Products, Inc.

B. Description:
   1. Configuration: 12-inch wide UL Classified Universal Cable Runway, manufactured from 3/8-inch wide by 1-1/2-inch high tubular steel with 0.065-inch wall thickness.
   2. Include Junction Splice Kit, Butt Splice Kit, and additional materials to comply with configuration shown on Drawings.
   3. Rung Spacing: 9 inches o.c.
   5. No portion of the rungs shall protrude below the bottom plane of side rails.
   6. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
   8. Straight Section Lengths: 10 feet except where shorter lengths are required to facilitate tray assembly.
   9. Width: 12 inches unless otherwise indicated on Drawings.
   11. Splicing Assemblies: Bolted type using serrated flange locknuts.
   12. Splice Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.03 WIRE-BASKET CABLE TRAYS
A. Products: Subject to compliance with requirements, provide the following:
   1. Chatsworth Products, Inc.

B. Configuration: Wires are formed into a standard 2-by-4-inch wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.

C. Materials: High-strength-steel longitudinal wires with no bends.

D. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.

E. Sizes:
   1. Straight sections shall be furnished in standard 118-inch lengths.
   2. Wire-Basket Depth: 4-inch (100-mm) usable loading depth by 8 inches, 12 inches, 18 inches, or 24 inches, wide.

F. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.

G. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

H. Hardware and Fasteners: ASTM F 593 and ASTM F 594 stainless steel, Type 316.

2.04 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. 

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

PART 3 - EXECUTION

3.01 CABLE TRAY INSTALLATION

A. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

B. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

C. Remove burrs and sharp edges from cable trays.

D. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.

E. Fasten cable tray supports to building structure.

F. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb.
G. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Do not install more than one cable tray splice between supports.

J. Support wire-basket cable trays with center support hangers, or trapeze hangers.

K. Support center support hangers and trapeze hangers for wire-basket trays with 3/8-inch diameter rods.

L. Make changes in direction and elevation using manufacturer's recommended fittings.

M. Make cable tray connections using manufacturer's recommended fittings.

N. Install cable trays with enough workspace to permit access for installing cables.

O. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

3.02 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with control conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.03 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on vertical runs to cable trays every 18 inches.
C. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.

D. In existing construction, remove inactive or dead cables from cable trays.

3.04 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
   2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
   3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
   4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
   5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
   6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
   7. Check for improperly sized or installed bonding jumpers.
   8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
   9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
   10. Prepare test and inspection reports.

3.06 PROTECTION

A. Protect installed cable trays and cables.

B. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
C. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
D. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION
SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Provide labor, materials, and equipment for the complete installation of work called for in the Contract Documents.
   2. Minimum requirements for equipment and cable installations in telecommunications rooms, server rooms, entrance facilities and communications equipment rooms.
   3. Minimum composition requirements and installation methods for the following:
      a. Cabinets
      b. Equipment Racks

1.02 SUBMITTALS

A. Provide product data for the following:
   1. Manufacturer's data/cut sheets, product drawing/specifications and installation instructions for all products (submit with bid).

1.03 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the owner or owner representative.

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of:
   2. TIA – 569-B Commercial Building Standard for Telecommunications Pathways and Spaces, 2004
PART 2 - PRODUCTS

2.01 CABINETS

A. Equipment Racks

1. Provide freestanding equipment cabinets to store computer, data storage and networking equipment in the data centers, computer rooms and equipment rooms. Each cabinet enclosure shall have a rectangular frame with removable top panel, side panels and doors. Installed cabinets shall include thermal, power, and cable management accessories that control airflow through the cabinet and keep network and power cables separate and organized.

2. The cabinet frame shall be rectangular with four corner posts, manufactured from steel and aluminum with welded and bolted frame construction. The horizontal frame members shall be aluminum extrusion with grooves that accept captive hardware to allow attachment of equipment mounting rails and thermal, cable and power management accessories. The captive hardware will slide within the groove allowing rails and accessories to be adjusted in depth without removal from the cabinet. The slide extrusions will be marked with a scale that allows easy top-to-bottom alignment of mounting rails and other accessories when adjusted in depth. The cabinet frame shall support 2500 lb (1134 kg) of equipment.

3. Provide and install cabinets in TER room as shown on drawings.

4. Anchor the cabinets in accordance with OSHPD Seismic requirements.

5. Each cabinet shall include two pairs of equipment mounting rails. Mounting rails shall bolt to the side of the cabinet frame at the top and bottom of the frame and shall be adjustable in depth to provide front and rear support for equipment. Equipment Mounting Rails shall be spaced horizontally to support 19" (482.6 mm) wide EIA-310-D compliant rack-mount equipment and shall provide up to 38.4" (976 mm) of rail-to-rail depth for equipment. Mounting rails shall be square-punched according to the EIA-310-D Universal hole pattern with equipment mounting holes on alternating 5/8" – 5/8" – 1/2" (15.9 mm – 15.9 mm – 12.7 mm) vertical hole centers. Square-punched holes shall accept cage nut hardware with various threads. Rack mount spaces or units (RMU) shall be 1-3/4" (44.45 mm) high and shall be marked and numbered on the mounting rails. Numbering shall start at the bottom of the rail. Mounting rails shall provide 45 RMU for equipment.

6. The cabinet shall include a solid top panel with two 3" x 11.5" (76 mm x 292 mm) cable access ports located near the rear corners of the frame. Each cable access port shall be plastic with a brush seal to allow easy addition and removal of cables while limiting bypass airflow.

7. The cabinet shall include two locking solid side panels with spring loaded latches for easy installation and removal. The cabinet shall be designed to allow baying with or without side panels installed.
The cabinet shall include a single front door with a perforated metal panel, hidden tamper-resistant hinges with quick-release hinge pins and a swing handle. The door shall be removable and reversible to open from the right or left. The door shall open to 150° when the cabinet is bayed with other cabinets. The front door shall have a single-point slam latch with a keyed lock.

The cabinet shall include a single perforated metal rear door with a swing handle. The door shall be removable and reversible to open from the right or left. The door shall open to 175° when the cabinet is bayed with other cabinets. The rear door shall have a single-point slam latch with a keyed lock.

The cabinet frame and door frames shall be manufactured from steel and aluminum. The top panel and side panels shall be manufactured from steel. Door panels shall be steel or Lexan. The door handle, side panel latches, rear door hinges and top panel cable access ports shall be plastic. The cabinet frame and front door shall be welded and bolted. The rear door shall be welded. Cabinet components shall assemble with hardware.

The mounting rails, top panel, side panels and doors shall be electrically bonded to the cabinet frame. The cabinet frame shall have a prepared location for attaching a grounding lug.

The cabinet shall be UL Listed as an Information Technology and Communications Equipment Cabinet, Enclosure and Rack System to standard UL 60950 under category NWIN. UL Listing will be stated in the manufacturer’s product literature.

The metal components of the cabinet frame, top panel, side panels, and doors shall be painted black with epoxy-polyester hybrid powder coat paint. The mounting rails shall be zinc-plated and silver-colored. Plastic components shall be black.

The cabinet shall include (4) leveling feet, (4) clamps for securing the leveling feet to the floor and a grounding lug for bonding the cabinet frame to the Telecommunications Grounding Busbar. The manufacturer of the cabinet shall sell compatible casters and equipment mounting hardware as an accessory.

Design Make shall be:

a. WDM Zone 4 Cabinet and accessories as necessary

2.02 EQUIPMENT RACKS

A. Equipment Racks

1. Racks shall be manufactured from aluminum and/or steel extrusions.
2. Each rack will have two L-shaped top angles, two L-shaped base angles and two C-shaped equipment-mounting channels. The rack will assemble with bolt hardware. Equipment-mounting channels will be threaded for easy assembly. The base angles will be pre-punched for attachment to the floor.
3. Equipment mounting channels will be 3” deep and punched on the front and rear flange with the EIA-310-D Universal hole pattern to provide 45, 48, 51 or 58 rack-mount spaces for equipment. Each mounting space will be marked and numbered on the mounting channel.
4. When assembled with top and bottom angles, equipment-mounting channels will be spaced to allow attachment of 19” EIA or 23” rack-mount equipment. Attachment points will be threaded with 12-24 roll-formed threads. The rack will include assembly and equipment-mounting hardware. Each rack will include 50 each combination pan head, pilot point mounting screws.
HMC Architects

5. The assembled rack will measure 7’ (84”) high, 7’6” (90”) high, 8’ (96”) high or 9’ (108”) high, 20.3” wide or 24.3” wide, and 15” deep. The sides (webs) of the equipment-mounting channels will be punched to allow attachment of vertical cable managers along the sides of the rack or for rack-to-rack baying.

6. The rack will be rated for 1,500 lb. of equipment.

7. The rack will be UL Listed.

8. Finish shall be either clear grained aluminum or epoxy-polyester hybrid powder coat in the color as specified below.

9. Design Make:
   2.02.1.1.1.1 Chatsworth Products, Inc. (CPI), Universal Self-Support Rack (or approved equal)
   (1) Part Number 46353-203, Universal Rack

2.03 WIRE MANAGERS

A. Vertical Wire Managers

1. Provide and install (6) double-side vertical wire managers in each of the TR rooms from 1st through 9th floor.

2. Position the wire managers on the ends of the row and between the equipment racks.

3. Offset the vertical wire managers to the first set of mounting holes on the vertical cable manager.

4. Install dividers for the vertical wire managers in the rear set of mounting holes. Refer to the room layout for the orientation of the equipment racks.

5. Design Make:
   2.03.1.1.1.1 Chatsworth Products, Inc. (CPI), Evolution Wire Manager
   (1) Part Number 35522-703

PART 3 - EXECUTION

3.01 Free-standing Universal Racks

A. Assemble relay racks according to manufacturer’s instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.

B. All racks must be attached to the floor in four places using appropriate floor mounting anchors. When placed over a raised floor, threaded rods should pass through the raised floor tile and be secured in the structural floor below. (Use CPI Part Number 40604-003 for concrete slab floors)

C. Racks shall be grounded to the TGB and or TMGB using appropriate hardware provided by the contractor. The ground will meet local code requirements and will be approved by the Authority Having Jurisdiction (AHJ).

D. In seismic areas, the rack should have additional bracing as required by building codes and the recommendations of a licensed structural engineer.

1. Ladder rack may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.
HMC Architects

2. The equipment load should be evenly distributed and uniform on the rack. Place large and heavy equipment towards the bottom of the rack. Secure all equipment to the rack with equipment mounting screws.

3.02 INSTALLATION

A. Install and tighten high strength bolts to the snug tight condition, in conformance with AISC Specification for Structural Joints using ASTM A325 or A490 Bolts. If Tension Control Bolts or Load Indicator Bolts are used, bolts shall be installed following recommendations of manufacturer. Hardened steel, round, flat washer shall be used under each nut and bolts shall be tightened until wrench twists of spliced ends.

B. Install per approved structural requirements as defined by the project structural review.

END OF SECTION
SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL
1.01 SUMMARY

A. Section Includes:
   1. Requirements for the installation of a TIA/EIA standard interior (inside plant) communications cabling system.
   2. Reference the Construction Drawings for further requirements. In the event of any conflicting requirements, the most stringent requirement will apply.

1.02 SUBMITTALS

A. Provide submittal information for the following submittal sections as described below:
   1. Product Data
   2. Shop Drawings:
      a. Cable routing and Grouping Plan
   3. Samples: Provide one full size installation sample/mock-up for each of the following components. All samples are to be fully labeled and shall be complete with all associated components necessary to make a complete mock-up. Samples will be used to set the standard for the quality of work required of the Contractor throughout the project. Installation work not meeting the sampled standard will be rejected and shall be replaced by the Contractor at no additional cost to the Owner
      a. Copper Backbone Cable: Provide a 24-inch length of each type of copper backbone cable. The outer jacket shall be stripped back 6 inches from one end to allow the individual pairs to be inspected. Label each cable per the Specifications. The sample shall show all cable markings.
      b. Fiber Backbone Cable: Provide a 24-inch length of each type of fiber backbone cable. The outer jacket shall be stripped back 12 inches from one end to allow the individual fiber sub-cable groups to be inspected for all cables. Label each cable per the Specifications. The sample shall show all cable markings.

PART 2 PRODUCTS
2.01 SUMMARY

A. Communication cabling system components shall be sourced (manufactured) by formally partnered Manufacturers (collectively referred to as the “Manufacturer”). Products shall not be intermixed between different manufacturers unless the Manufacturer of the chosen communications cabling system has listed (in writing) another manufacturer’s component as an “Approved Alternative Product” and will warrant the “Approved Alternative Product” as part of the Manufacturer’s extended Warranty.
B. For all cabling products shall be engineered “end-to-end” (i.e. the system and all of its components shall be engineered to function together as a single, continuous transmission path).

C. The Contractor shall physically verify the following materials on site, prior to purchase and delivery of the materials:
   1. Lengths of conduit and/or pathway are to be used for routing backbone cabling. Precut materials of insufficient length are the sole responsibility of the Contractor.
   2. Fill ratio and overall suitability of raceway for installation of inside plant cabling. The Contractor shall promptly notify the Engineer of potential overfill, potential for installation problems due to overfill, or raceway which may be otherwise deemed by the contractor unsuitable for use, and shall await the Engineer’s direction prior to purchase and delivery of the materials.

2.02 GENERAL

A. The horizontal cabling is installed in a star topology with a dedicated cable to each jack. It extends from the work area outlet (WAO) to the telecommunications room (TR). Horizontal Cabling Systems shall meet requirements as specified in ANSI/TIA/EIA 568.

B. No telecommunications cable shall be run adjacent and parallel to power cabling. A minimum of 5" distance is required from any fluorescent lighting fixture or power line up to 2kVA and 24" from any power line over 5kVA. Similarly, cable should be routed and terminated as far as possible from sources of EMF, such as ballasts, generators, fans, motor control units, motors, etc.

C. All wiring shall be run concealed, inside wall cavities and in ceiling plenum. Any deviation from this needs to be discussed with college IT designee.

D. Horizontal cabling shall terminate in the IDF on the same floor as the WAO.

E. As part of the construction process for renovation, project plans shall include the removal of any abandoned cable(s) that shall be in the space. The 2005 California Electrical Code requires removal of accessible abandoned cable. All cabling reserved for future use, shall be identified as such and tagged.

2.03 CABLEING

A. Copper Multipair for Telephones:
   1. Copper backbone (riser) cabling shall be Category 3 Unshielded Twisted Pair (UTP) Multi-pair, 4 AWG, solid copper cable formatted into 25 pair binder groups.

B. Optic Fiber Riser will be used for data networking and other high speed applications and shall consist of a minimum of six multimode (50/125um) and minimum six Single-mode (8.31125nm) optic fibers and be terminated on each floor as design requires. The minimum standard Optic Fiber is a Corning riser or plenum rated tight buffer, 12 fiber cable per destination TR.
2.04 PATCH PANELS

A. Fiber Patch Panels: Patch panels shall be used to terminate multimode fiber backbone cables and shall be sized (port/fiber count and rack units) as denoted in the Contra Costa Community College District Infrastructure Standard document. Fiber patch panels shall consist of enclosures pre-assembled with connector panels, blank connector panels (for unused connector slots), strain relief, rack or wall mountable as shown on the Drawings. Fiber patch panels shall be complete with fiber optic receptacle adapters and with all incidental materials necessary for mounting.

B. Copper Patch Panels: Patch panels shall be rack mountable and sized as shown on the Drawings. Patch panels shall support a universal (T568B) wiring pattern, shall exceed the transmission requirements for connecting hardware as specified in the TIA/EIA standards for the Category for which they are rated, and shall be complete with pre-manufactured cable management for supporting cables behind the patch panel and with all incidental materials necessary for mounting.

C. Copper Patch Panels have been identified for Category 3 Backbone Distribution: Telco-style Modular Patch Panels shall be rack-mountable and sized as shown on the Drawings.

D. Cable Support Bar/Strain Relief: Provide per manufacturer recommendations.

2.05 CONNECTORS

A. Fiber Connectors: Fiber connectors shall be LC connectors. Fiber connectors shall meet or exceed the transmission requirements for connecting hardware as specified in the TIA/EIA 568-B standards.
   1. Multimode; Provide LC connectors and 24-port modular inserts for 50/125 µm multimode fiber.

B. Patch Panels: Patch panels shall be used to terminate fiber backbone cables and shall be sized (port/fiber count and rack units) as shown on the Drawings. Fiber patch panels shall consist of enclosures pre-assembled with connector panels, blank connector panels (for unused connector slots), strain relief, rack or wall mountable as shown on the Drawings. Fiber patch panels shall be complete with fiber optic receptacle adapters and with all incidental materials necessary for mounting.

2.06 CABLE ASSEMBLIES (PATCH CORDS) AND CROSS-CONNECTS

A. Copper Patch Cables: Contractor shall provide all patch cords and cross-connects required for 100% cable assembly. Provide per Division 27 Section 271500 Communications Horizontal Cabling.
   1. Station Patch Cords
      a. Provide but do not install 14’ patch cords.
      b. Patch cord color will be determined by local EUS at the rack and stack project phase.
      c. Patch cord quantity shall be coordinate with District
   2. Access Switch Patch Cords
a. Provide but do not install 7’ patch cords.
b. Patch cord color will be determined by local EUS at the rack and stack project phase.
c. Patch cord quantity shall be coordinate with District

B. Fiber Patch Cables: Contractor shall provide all patch cords and cross-connects required for 100% cable assembly. Provide per Division 27 Section 271500 Communications Horizontal Cabling.
   1. Provide but do not install (4) 3 meter duplex OM3 fiber jumpers with LC terminations at both ends.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall pay particular attention to and comply with the applicable portions of the following:
   1. TIA/EIA-568-B: Commercial Building Telecommunications Cabling Standard
   2. TIA/EIA-606-A: Administration Standard for Commercial Telecommunications Infrastructure
   3. J-STD-607-A: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   4. TIA/EIA-455: Fiber Optic Test Standards
   5. TIA/EIA-526: Optical Fiber Systems Test Procedures
   6. IEEE 802.3 (series): Local Area Network Ethernet Standard, including the IEEE 802.3z Gigabit and 802.3ae 10 Gigabit Ethernet Standard
   8. Manufacturer Recommendations and Installation Guidelines
   9. Contra Costa Community College District Infrastructure Standard

B. Connectors:
   1. The Contractor shall visually check fiber connectors and/or splices after connecting and/or splicing with a minimum 200x magnification microscope to ensure that no physical damage has occurred during the installation process.
   2. Fiber splices shall be fusion spliced and shall be required for all single mode fiber strands. Mechanical splices are not acceptable. Each fusion splice shall be protected in a splice tray or similar protective device that is designed to mount within the enclosure. Bare/stripped optical fiber strands shall be protected with a heat shrink or silicon adhesive to prevent exposure to moisture.

C. Copper Termination Blocks:
   1. Cable shall be routed in cable in cable tray/ladder rack and terminate in rack mount copper patch panel as specified above.
   2. Patch Panel punch downs shall be as follows:
      a. Punch down cable sequentially across the patch panel or termination field.
      b. Punch down cable using only the selected communication cabling system Manufacturer approved impact tool.

D. Cable:
   1. General (applicable to all cable types):
a. Cable shall be installed in strict compliance with the manufacturer’s recommendations.
b. Maintain separation from other conductors (power, fire alarm, etc.) per NEC requirements and TIA/EIA standards.
c. The bending radius and pull strength requirements of all cable as detailed in the TIA/EIA standards and the manufacturer’s installation recommendations shall be strictly observed during handling and installation.
d. Pull cables simultaneously where more than one cable is being installed in the same raceway.
e. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation (Polywater, or approved equal).
f. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cable or raceway.
g. Cable jackets shall not be twisted during installation. Cables showing evidence of twisting shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
h. Cable shall be installed in a continuous (non-spliced) manner unless otherwise indicated.
i. Cable installed in conduit and/or ducts:
   (1) Fill ratios shall not exceed NEC requirements.
   (2) Cable shall not be pulled into conduit/ducts until the conduit/duct ends have been prepared for cable installation (i.e. reamed to eliminate sharp edges and insulated throat bushings installed). Cables pulled into conduit/ducts prior to conduit/duct end preparation shall be replaced at no additional cost to the Owner.
   (3) Reinstate pull-wires in conduits and ducts after use to facilitate future addition of cables.

j. Cable installed in cable tray/ladder rack:
   (1) Cable shall not be attached to the cable tray (i.e. cable shall be left “loose”) with the exception of cable installed in cable tray (cable runway) within telecommunications rooms (see “Cable in telecommunications rooms” below).
   (2) Cable shall be laid in tray in such a way as to present a neat and professional appearance.
   (3) For cable tray serving both backbone (riser) and horizontal cabling, install cable in cable tray in such a manner that backbone cabling does not overlap with horizontal cabling – reserve approximately one-fourth of the space in the tray for backbone cabling and the remaining three-fourths for horizontal cabling.
   (4) Where cables in cable trays are required to maintain specific distances between each other, they shall be firmly secured to maintain this distance at fire rated penetrations.

k. Cable not installed in conduits/ducts or cable tray:
   1) Cables shall be strapped, fastened for support. Staples and/or tie wraps are not acceptable:
(1) Straps, fasteners shall not be over-tightened. Cables showing evidence of over-tightening shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.

(2) Straps, fasteners installed in plenum spaces shall be plenum rated.

(3) Reusable Velcro hook and loop style cable straps/fasteners shall be used within telecommunications rooms. The use of plastic tie wraps is not acceptable on any portion of the installation (see “Cable in telecommunications rooms” below).

(4) Cables shall be bundled by application (horizontal or backbone) and by cable type (Cat 3, Cat 6A UTP, MM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.

l. Cables in suspended cable runs shall be supported at varying intervals. Cable spans shall be limited to 5 feet or less, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – “exact” spans can degrade cable performance).

m. Cable installed on exposed surfaces or structural members shall be installed parallel and perpendicular to the surfaces. Surface contours shall be followed wherever possible. Cables shall be attached to surfaces at intervals not to exceed 3 feet.

n. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable.

2. Cable in telecommunications rooms:
   a. Cable straps: Install per Division 27 Section 271100 – Communications Equipment Room Fittings.
   b. Cable on backboards:
      (1) Lay and dress all cables to allow other cables to enter raceway (conduit or otherwise) without difficulty at a later time by maintaining a working distance from these openings.
      (2) Cable shall be routed as close as possible to the ceiling, floor, sides, or corners to insure that adequate wall or backboard space is available for current and future equipment and for cable terminations.
      (3) Lay cables via the shortest route directly to the nearest edge of the backboard from mounted equipment or blocks. Secure all similarly routed and similar cables together and attach to D-rings vertically and/or horizontally, then route over a path that will offer minimum obstruction to future installations of equipment, backboards or other cables.

3. Cable Slack
   a. Provide cable slack (service loops) at cable ends (both ends) to accommodate future cabling system changes.
   b. Provide slack length as follows:
      (1) For fiber: Provide a minimum of 25 feet.
      (2) For copper and coaxial: Provide a minimum of 25 feet.

E. Fiber Cable:
   1. General
a. All fiber strands within a fiber cable shall be connectorized. The installation of “dark fiber” is not acceptable.
b. The cable contractor shall provide 10’ service loops in TR’s and the TER. The contractor shall also provide 5’ of slack on the fiber drum inside the termination shelf after the cable sheath is removed. Additional slack provided in the pigtail cartridge.
c. Splices shall be fusion spliced. Mechanical splices are unacceptable.
   (1) Fusions splices shall be placed in splice trays in wallets or Rolo-Splice kits as appropriate for each type of termination shelf or splice enclosure.
d. Attach a Panduit PST-FO Tag to exposed fiber optic cables every 10’ along the exposed length. Label each tag with “To” and “From” Room ID, stand count and fiber type. For vertical runs provide one label at 5’ AFF +- 6 inches.
e. Secure trunk cables with strain relief.

F. Copper Cable:
   1. All pairs within a cable shall be terminated. Un-terminated cable pairs are not acceptable.
   2. Provide strain relief at the patch panels to ensure durable connections.
   3. For shielded cable, bond both ends of the metallic shield (or metallic strength member) to the nearest TGB.

END OF SECTION
SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLEING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. The requirements of the GENERAL CONDITIONS, SUPPLEMENTARY
      CONDITIONS, AND DIVISION 01 of the Specifications apply to the Work of this
      Section.
   2. Provide all labor, materials, and equipment for the complete installation of work
      called for in the Contract Documents.

1.02 SYSTEM DESCRIPTION

A. Furnish and install complete permanent link Structured Cabling System (SCS). The
   SCS shall serve as a vehicle for transport of data, video and voice telephony signals
   throughout the network from designated demarcation points to outlets located at
   various workstations and other locations as indicated on the contract drawings and
   described herein.

B. Wiring utilized for data and voice communications shall originate at owner provided
   networking equipment either in vertical equipment racks located at the
   Telecommunications Room (TR) location(s). Telecommunication Outlets (TO) shall be
   furnished, wired and installed by the SCS system contractor. All cables and
   terminations shall be identified at all locations.

C. All cables shall terminate in an alphanumeric sequence at all termination locations.

D. All balanced twisted pair cable terminations shall comply with, and be tested to
   TIA/EIA568-B standards for Category 6 requirements in ANSI/TIA-568-C.2, CENELEC
   EN-50173 series, and ISO 11801:2002 including amendments 1 and 2 installations

1.03 SUBMITTALS

A. Provide product data for the following:
   1. Manufacturer’s data/cut sheets, product drawing/specifications and installation
      instructions for all products (submit with bid).

1.04 QUALITY ASSURANCE

A. All cable and equipment shall be installed in a neat and workmanlike manner. All
   methods of construction that are not specifically described or indicated in the contract
   documents shall be subject to the control and approval of the owner or owner
   representative.
HMC Architects

B. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed. Where “approved equal” is stated or a substitution is requested, equipment shall be equivalent in every way to that of the equipment specified. All substitutions are subject to the control and approval of the owner or the owner representative.

C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing communications/data cabling.

D. Material and work specified herein shall comply with the applicable requirements of:
2. TIA – 569-B Commercial Building Standard for Telecommunications Pathways and Spaces, 2004
5. NFPA 70 – National Electric Code, 2005
7. NEMA – VE-1 – Metal Cable Tray Systems, 2002
8. NEMA – VE-2 – Metal Cable Tray Installation Guidelines, 2001
9. Contra Costa Community College District Infrastructure Standard

PART 2 PRODUCTS

2.01 GENERAL

A. All voice and data communication cabling shall meet or exceed Category 6A requirements.

B. Provide and install a minimum of two cables to each work area outlet unless otherwise note.

C. Where cable bundles branch off from main pathway, contractor shall provide and install 2" j-hooks supported by independently installed ceiling wired. The J-hook support wired must be attached at both ends. This support system shall be considered the secondary pathway.

2.02 CABLE AND CONNECTIVITY

A. Copper cabling shall be Category 6A UTP
   1. Category 6A cable
   2. Terminate the cables in the 568B wiring configuration.
   3. Color to be specified by Owner.

B. Copper patch panels
   1. Provide and install Belkin CAT6A patch panels as required to terminate the cables and allow for 30% growth.
HMC Architects

2. Terminate the cabled from a work area outlet on adjacent positions of the patch panels as described in the District Infrastructure Standard.

C. Modulate Jack Insert
1. Provide and install modular outlets and terminate the cables in 568B configuration.
2. Match the modular outlet color to the cable color.
3. Insert the jacks in the faceplates using the two top ports with the white modular outlet on the left when viewed from the front.
4. Provide machine printed labels using black lettering on clear tape with a 12 point font. Paste the label to the white paper strip behind the clear escutcheon strip.

D. Wireless Access Point
1. Provide and install (1) CAT6A cable to each of the access point locations.
2. Provide 20’ of cable neatly coiled at the designated access point or AMS location and secure the bundle with Velcro cable ties.
3. Provide and install CAT6A patch panels and terminate the AP and AMS cables sequentially.

PART 3 EXECUTION

3.01 CONTRACTOR

A. The contractor selected to provide the installation of this system shall be certified by the manufacturing company in all aspects of design, installation and testing of the products described herein.

B. Route the horizontal cabling through accessible ceiling and use j-hook support installed by others.

C. Do not use ceiling support to support cabled.

D. Bundle the horizontal cabling using plenum rated Velcro cable ties. Cable ties shall be used for bundling only and not for cable support.

E. Provide a 2’-3’ service coil loop at the top of the conduit stub at the work area outlet and secure the cables at the top of the stub using plenum rated Velcro cable ties.

F. The contractor shall utilize the authorized manufacturer components and distribution channels in provisioning this Project.

G. Contractor shall have a minimum of five (5) years of recent experience on structured cabling systems of similar type and size.

H. Contractor and design firm shall be in compliance with all federal, state and local statutes regarding qualifications of firms.

I. The contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.
HMC Architects

J. The contractor shall own and maintain the tools and equipment approved by the cabling system manufacturer for successful installation and testing of Category 6 balanced twisted pair distribution systems.

K. The contractor shall have personnel who are adequately trained in the usage of such tools and equipment.

L. Contractor shall submit a resume of qualification with the Contractor's proposal indicating the following:
   1. A list of recently completed projects of similar type and size with contact names and telephone numbers for each
   2. A list of test equipment proposed for use in verifying the installed integrity of metallic and fiber optic cable systems on this project.

3.02 CABLE

A. General (applicable to all cable types) Cable shall be installed in strict compliance with the manufacturer's recommendations.

B. Maintain separation from other conductors (power, fire alarm, etc.) per NEC requirements and TIA/EIA standards.

C. The bending radius and pull strength requirements of all cable as detailed in the TIA/EIA standards and the manufacturer's installation recommendations shall be strictly observed during handling and installation.
   1. Pull cables simultaneously where more than one cable is being installed in the same raceway.
   2. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation (Polywater, or approved equal).
   3. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cable or raceway.

D. Cable jackets shall not be twisted during installation. Cables showing evidence of twisting shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.

E. Cable shall be installed in a continuous (non-spliced) manner unless otherwise indicated.

F. Cable installed in conduit and/or ducts:
   1. Fill ratios shall not exceed NEC requirements.
   2. Cable shall not be pulled into conduit/ducts until the conduit/duct ends have been prepared for cable installation (i.e. reamed to eliminate sharp edges and insulated throat bushings installed). Cables pulled into conduit/ducts prior to conduit/duct end preparation shall be replaced at no additional cost to the Owner.
   3. Reinstate pull-wires in conduits and ducts after use to facilitate future addition of cables.
   4. Standard in-wall communication outlets shall be installed in a 4” x 4” x 2.4” device box with 1” conduit stubbed to above ceiling.
G. Cable installed in cable tray:
   1. Cable shall not be attached to the cable tray (i.e. cable shall be left “loose”) with
      the exception of cable installed in cable tray (cable runway) within Telecom
      Rooms (see “Cable in Telecom Rooms” below).
   2. For performance reasons, station cable in tray shall not be combed.
   3. Cable shall be laid in tray in such a way as to present a neat and professional
      appearance

H. Cable NOT installed in conduit/ducts or cable tray:
   1. Cables shall be strapped or fastened for support. Staples and plastic cable ties
      are not acceptable.
      a. Straps and fasteners shall not be over-tightened. Cables showing
         evidence of over-tightening shall be replaced at no additional cost to the
         Owner, regardless of the outcome of cable testing.
      b. Straps, fasteners, and tie-wraps installed in plenum spaces shall be
         plenum rated.
      c. Reusable Velcro hook and loop style cable straps/fasteners shall be used
         within Telecom Rooms. The use of plastic tie wraps is not acceptable
         within Telecom Rooms (see “Cable in Telecom Rooms” below).
      d. Cables shall be bundled by application (horizontal or backbone) and by
         cable type (Cat 3, Cat 6 UTP, MM Fiber, SM Fiber, etc.). Cable
         applications and types shall not be intermixed within a bundle.
   2. Cables in suspended cable runs shall be supported at varying intervals. Cable
      spans shall be limited to 5 feet or less, and the length of spans shall vary along
      the cable path (i.e. a given span should not be exactly the same length as the
      span preceding or following it – “exact” spans can degrade cable performance).
   3. Cable installed on exposed surfaces or structural members shall be installed
      parallel and perpendicular to the surfaces. Surface contours shall be followed
      wherever possible. Cables shall be attached to surfaces at intervals not to
      exceed 3 feet.
   4. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or
      the ceiling support system (grids, hanger wires, etc. – with the exception of
      ceiling support anchors) is not acceptable.

I. Cable installed in Telecom Rooms
   1. Cable on backboards:
      a. Lay and dress all cables to allow other cables to enter raceway (conduit
         or otherwise) without difficulty at a later time by maintaining a working
         distance from these openings.
      b. Cable shall be routed as close as possible to the ceiling, floor, sides, or
         corners to insure that adequate wall or backboard space is available for
         current and future equipment and for cable terminations.
      c. Lay cables via the shortest route directly to the nearest edge of the
         backboard from mounted equipment or blocks. Secure all similarly routed
         and similar cables together and attach to D-rings vertically and/or
         horizontally, then route over a path that will offer minimum obstruction to
         future installations of equipment, backboards or other cables.

J. Cable terminating on patch panels located on racks.
1. Route cables in Telecom Rooms to patch panels on racks by routing across cable runway to top of rack and then down vertical cable management sections to patch panel.

K. **Cable Slack:**
   1. Provide cable slack (service loops).
   2. Provide slack length as follows:
      a. At the device box: Provide a minimum of 12 inches. Do not form a loop with the cable slack. Excess cable shall be pushed up the conduit.
      b. In the Telecom Room: Route cable around ladder rack to provide a 10' slack loop.

3.03 **LABELS**

   A. Labeling must be done in ascending campus room number, not drawing or architect room numbers. No tables or translations will be accepted.
   1. TR Room number (where cable terminates), Room number of the work area, Station Number, Jack Number (Prefixed with type "V" for voice, "D" for data) (Example: 109 122-1-V1 109 is the TR, 122 is the room where the jack is located, 1 is the station location, V1 is the 1st voice jack in that particular wall plate)
   2. All labeling shall be done with typed inserts, typed on adhesive labels, or pre-stamped jack usage indicators for patch panels. For cabling the labeling shall be printed heat shrink labels or typed adhesive labels specifically designed for cabling. Handwritten labels are not allowed.
   3. Post one full size plot (42x30) of as-built drawings, specifically the floor plans, and (as applicable) reflected ceiling plans, within IDFs such that show the IDF's serving area. Coordinate location of posting with Owner.
   4. Submit a "cable ID-to-Office number key" as an electronic file in an MS-Excel spreadsheet file format containing a list of every cable identifier associated with the final office number. This should be the Jack Table referenced in 11.7.

3.04 **BONDING**

   A. All cable trays and conduits shall be bonded.
   
   B. Telecommunications equipment shall be bonded per the manufacture's guidelines.
   
   C. TR racks shall be bonded.

3.05 **INSPECTIONS, TESTING, AND ACCEPTANCE**

   A. Frequent inspections should be conducted during the installation of the new services and wiring. These inspections should be conducted jointly by the contractor and representatives from the CCCCD IT & Facilities Departments.
   
   B. Frequent inspections should be conducted during the installation of the new services and wiring. These inspections should be conducted jointly by the contractor and representatives from the CCCCD IT & Facilities Departments.
C. Acceptance testing of all installed and terminated structured cabling systems, including UTP and fiber Optic cable, shall be completed and both a hard copy and electronic copy.

D. Horizontal data structured cabling permanent links shall be tested for acceptance.

E. All required test results shall be delivered to the CCCCD Facilities and designated IT representative.

F. At the completion of each installation "As Built" prints and other supporting documentation shall be provided by those performing work specified according to 606A standards. A complete set of 100% prints and documentation shall be provided to the CCCCD Facilities for review and will be maintained on file.

3.06 WARRANTY

A. Contractor shall certify and provide all manufacturer’s warranties.

END OF SECTION
SECTION 27 15 43
FACEPLATES AND CONNECTORS

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Provide all services, labor, materials, tools, and equipment required for the complete and proper installation of new faceplates and proper termination of new connectors specified in this section of the Division 27 specifications and accompanying construction drawings
B. Related Section:
   1. Section 27 00 00 - Communications
   2. Section 27 05 33 - Conduits and Backboxes for Communications Systems
   3. Section 27 15 13 - Communications Copper Horizontal Cabling
   4. Diablo Valley College District Standards

1.02 QUALITY CONTROL
A. Comply with Section 27 00 00 - Communications.

1.03 WARRANTIES
A. Comply with Section 27 00 00 - Communications.

1.04 MATERIAL SUBSTITUTIONS
A. Comply with Section 27 00 00 - Communications.

1.05 SUBMITTALS
A. Comply with Section 27 00 00 - Communications.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Comply with Section 27 00 00 - Communications.

PART 2 - PRODUCTS

2.01 QUANTITY
A. See drawings
B. Or equal as approved in accordance with Division 01 General Requirements for substitutions.

2.02 FACEPLATES

A. Work Area Faceplates: Shall be double gang with 4 (each) jack openings. Color- White

2.03 CONNECTORS

A. Furnish all required UTP CAT 6 modular jacks, 8 position, 8 conductor. See Appendix III of the Campus Infrastructure Standards for pair order.

PART 3 - EXECUTION

3.01 GENERAL

A. For all cable types, connector installation execution shall comply with connector manufacturer's installation specifications, instructions, and recommendations.

3.02 EXAMINATION

A. Verify site conditions.

B. Comply with Section 27.00 00 – Communications.

3.03 LABELING

A. TR Room number (where cable terminates), Room number of the work area, Station Number, Jack Number (Prefixed with type "V" for voice, "D" for data) (Example: 109 122-1-V1 109 is the TR, 122 is the room where the jack is located, 1 is the station location, V1 is the 1st voice jack in that particular wall plate)

B. TR Room number (where cable terminates), Room number of the work area, Station Number, Jack Number (Prefixed with type "V" for voice, "D" for data) (Example: 109 122-1-V1 109 is the TR, 122 is the room where the jack is located, 1 is the station location, V1 is the 1st voice jack in that particular wall plate)

C. Post one full size plot (42x30) of as-built drawings, specifically the floor plans, and (as applicable) reflected ceiling plans, within IDF's such that show the IDF's serving area. Coordinate location of posting with Owner.

D. All labels shall be machine created labels, clearly legible, black letters on white background. Brother P-Touch or equal.
HMC Architects

3.04 TESTING:
   A. Comply with Section 27 00 00 - Communications

3.05 AS-BUILT DRAWINGS
   A. Comply with Section 27 00 00 - Communications

3.06 VERIFICATION
   A. Comply with Section 27 00 00 - Communications

END OF SECTION
PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Summary:
   1. Supply and install a turnkey audiovisual system, to include equipment and materials, whether specifically mentioned herein or not, to ensure a complete and operating system.

B. Related work:
   1. Conduits, back-boxes behind displays, connection boxes, pull boxes, junction boxes, sleeves, A/V floor boxes, poke thru devices and outlet boxes permanently installed in floors, walls and ceilings
   2. All electrical breaker panels and power receptacles necessary to bring power to the audiovisual systems equipment racks and to devices in the Project as indicated in the drawings.
   3. All network-related CAT 6A Unshielded Twisted Pair (UTP) cabling, including that connecting audiovisual equipment to the LAN, including but not limited to touch panels, projectors, displays, control processors, DM switchers and Digital Signal Processors. Provide CAT 6A jumper cables, as needed, between audiovisual equipment and network terminations.
   4. Structural work, including steel backing, projector mount fastening and bracing.
   5. Control modules for shades and lighting. Provide connections to these modules from the control system in this specification.
   6. Electrical wiring of 120V connections for LCD display back-boxes, projection screen switches (mounting of screens is included in this specification).
   7. See Construction Documents for reference to items marked “Not In Contract” and/or “by others”.

C. Codes: Work shall be performed in accordance with applicable requirements of governing codes, rules and regulations including the following minimum standards, whether statutory or not:
   1. National Building Code (NBC)
   2. National Electrical Code (NEC)
   3. National Fire Code (NFC)
   4. Electronic Industries Association (EIA)
   5. International Standards Organization (ISO)

1.02 RELATED DOCUMENTS

A. Published specifications, standards, tests or recommended methods of trade, industry, or governmental organizations apply to work of this Section where cited by abbreviations noted below.
   1. ANSI/TIA/EIA-568-B.1 – Commercial Building Telecommunications Cabling Standards
2. ANSI/TIA/EIA-607 – Commercial Building Grounding and Bonding for Telecommunications
3. National Electrical Code (NEC)
4. California Building Code (CBC)
5. Underwriters Laboratories (UL)
6. AVIXA
7. BICSI – Building Industry Consulting Services Intl., Tampa, FL

B. Related Sections:
1. Division 26: Electrical Systems
2. Division 27: Communications

1.03 DEFINITIONS

A. “District”: The owner of the facility.

B. Scope of Work: This specification section defines certain audio, video, and control systems to be installed by an audiovisual systems contractor. Please see the “SYSTEM DESCRIPTION” section for specifics.

C. Terms:
1. "Shall" is mandatory; the term "will" is informative; the term "should" is advisory; and the term "provide" means furnish and install.
2. “Provide”: To supply all necessary labor and material, including miscellaneous material, accessories and appurtenances required to install, test, and make fully functional and ready for intended use.
3. “Install”: Same as “Provide”.
4. “Furnish”: To supply material only; no installation is required.
5. “Custom” indicates systems or components that shall be fabricated by the Contractor based on these specifications and drawings.
6. “A/R” (As Required): The quantities on most items are not specified in this specification, so the bidding contractor must refer to the drawings to determine how many items to supply.
7. "OFE" refers to Owner-Furnished Equipment, which are specified in other sections, or by some other means or procurement source.
8. “OFCI” refers to Owner-Furnished, Contractor-Installed equipment. Coordinate the integration of new components provided by the Owner. Provide required additional mounting hardware, etc. to ensure proper operation of the systems as specified.
9. "NIC" refers to work or equipment that is not in contract covered in this section.
10. “Future” indicates equipment that shall be added to the systems by the Owner or Owner representative at a later date. Provisions shall be made for this equipment.
11. The term "or equal" indicates equal in materials, size, color, design, function, efficiency of specified, and conforming with base bid manufacturer/model.
12. “Cabling System”: All required equipment and cabling including hardware, cable support, conduit, labeling, connectors, splitters, patch cords, modular AV connector plates, horizontal cabling installed and configured to provide connectivity between equipment locations.
13. Where definitions provided herein differ from those in other Sections, definitions in this Section will take precedence for work in this Section.
1.04 SUBMITTALS

A. Product Data: For each product indicated.
   1. Obtain written approval from the Consultant for the product data submittal prior to materials and equipment purchase order and prior to installation.
   2. Format: Submit each product data as an electronic (PDF) document.
   3. Labeling: For each submittal, provide a cover page including the following information:
      a. Client Name
      b. Project Name and Address
      c. Submittal Name (e.g., “Product Data Submittal for LCD Panel Backbox.”)
      d. Specification Section Number (e.g., “Section 27 05 33”)
      e. Date of Submittal
      f. Contractor Name

B. Shop Drawing Submittal
   When drawings are revised due to authorized changes via RFIs or Change Orders, resubmit these revised drawings.
   1. The shop drawing submittal should include a complete package of information required to build the system. If there are questions as to color, accessories to be provided, or coordination issues, these questions should have been asked and answered before the submittal is issued. No descriptions should include any note such as “per architect”, or “as required” except for cable.
   2. Provide overall floor plans of each floor of a building, including a site plan showing the location of the media pedestal and a roof plan showing location of the JCC-TV satellite dish. Denote each room with AV equipment, labeled with enlarged AV plan and functional drawing numbers.
   3. Provide enlarged AV floor plans and reflected ceiling plans indicating device locations with device legends indicating manufacturer and model number of each device.
   4. Provide enlarged AV plans and reflected ceiling plans showing infrastructure requirements to be provided by other trades in support of the AV system.
   5. Provide mounting details for all AV equipment and hardware.
   6. Provide functional single-line drawings. Include equipment names and model numbers. Clearly label each item of equipment shown on the drawing with the manufacturer’s terminal number or input/output designation (e.g., "Mic 1-In", or "Record Out-Left"). Label the room number of the equipment room on the drawing. Show the entire wire run from source, through the equipment room to the destination, on the same drawing to make it easier to follow signal flow.
   7. Provide a connection detail drawing showing how each conductor within each cable is terminated on every cable used in this project. Note where shields are connected and where they will float to ensure the integrity of the grounding system. Indicate cable types and, where appropriate, color codes. If the contractor has a standard termination drawing, confirm that it includes all terminations used on this project.
   8. Provide an IP address schedule showing every device connected either to the private AV or building wide Ethernet network. Include device description, location, IP address, subnet, default gateway, and MAC address.
9. Provide equipment rack elevations, both front and rear. Show equipment depth on side views. Avoid mounting shallow items between deep items (canyons) to improve access.

10. Provide full-scale drawings of custom wall plates, rack panels and button panels indicating exact lettering, critical dimensions, and finishes. Indicate location and quantity for each plate and panel. Engraving of each plate shall be unique in each space, (i.e. only one M1 in each space).

11. Provide cable run lists. Show “from” and “to” locations, cable part numbers, designations and descriptions. Clearly show at each terminal point the type of connector to be used. Assign wire numbers to every wire in the drawing corresponding to the same number on the functional drawing.

C. Control System Submittal
1. Prior to starting the design of the touch panel Graphical User Interface (GUI), obtain the template for courtroom design from the Judicial Council. In addition, inquire of the court if they have a GUI that they have used previously and are happy with.

2. Conduct a GUI coordination meeting with the court, Judicial Council and AV consultant to select an approach. If the template is not used at the request of the court, then all of the capabilities shown on the template should be included, if the design includes these capabilities.

3. After the basic approach has been selected, make the following submittals:
   a. Based on the selected approach, customize this design to conform to the requirements of this project, and submit a set of screen shots for the most complex courtroom design.
   b. Once comments on the courtroom GUI have been incorporated, revise and re-submit the GUI to include the remaining spaces within the courthouse that have AV control systems.
   c. Once the comments on the complete GUI design have been approved, write processor code to operate the GUI (but not the actual controlled devices). Load it into a processor on the internet, and submit the appropriate files necessary to simulate the actual operation of the touch panel on a computer.
   d. Submit an additional narrative describing what actions are initiated by other signals (i.e. partition sensors, teleconference in progress notification, shared resources being used etc.). Indicate what inputs result in what outcome.
   e. If the functioning GUI has been approved, proceed with the installation.

D. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required. Use room designations indicated on Drawings.

1.05 SOFTWARE

A. Ownership.
1. All control system, audio DSP and touch panel source code written for this project created by the AV contractor or their subcontractors shall be considered as a work for hire. This source code shall be supplied in electronic form along with the record as-built drawings in electronic form at the conclusion of the project to the Owner. Include any ancillary files necessary to modify and/or update the software using industry standard programs available to a trained programmer. The source code, or any modules included therein, shall not include any password protected...
content. If any modules or sub-routines are used, a help file shall be included describing the functions of each input and output.

2. If any subsequent changes are made to the code by the contractor or its subcontractors, updated code shall be supplied to the Owner in electronic form.

B. Touch Panel Design
1. All panels are to have the time and date displayed in the same position on every page.
2. All pages are to have a title, indicating the piece of equipment and/or functionality being controlled.
3. Each individual room type shall be given the same user interface design and layout, throughout the project, to the greatest extent practicable.
4. Each individual room type shall be given the same user interface design and layout, throughout the project, to the greatest extent practicable.
5. Whenever the same button appears on more than one page, it will be in the same position on each page.
6. Functions used during a general presentation shall be accessible with a minimal amount of button presses or page flips.

C. Control System Functionality
1. Clearing: Ensure that each media selection clears the previous audio and visual selection (i.e. Selecting COMPUTER will clear the audio as well as video section of the previous Blu-ray disk selection
2. Defaults: Establish default power-up conditions for the system including device audio levels, warm-up routine, power conditions, switcher status and other default conditions as required.
3. No settings of the volume controls should allow the audio system to go into feedback.
4. Failsafe: No operation or sequence of operations shall cause the control system to become inoperable or interfere with further processing, correct operations or execution of commands.
5. Display the accumulated lamp hours of all video projectors, if the projector has this capability.
6. If any touch panel is wireless, display a battery gauge.
7. Include the capability for automatically powering down all none-essential equipment supporting each individual room at a present time (i.e. 6:00pm) each day. Set time is user settable on the room page.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver products in factory containers. Store in clean, dry space in original containers

B. Racks should be assembled and cabled and pretested at the contractor’s shop prior to delivery onsite for installation.

1.07 RECORD DRAWINGS

A. Provide Record Drawings in accordance with Division 1 requirements. Separately, provide Record Drawings in accordance with this Section, Paragraph 1.08B
1.08 SYSTEM DESCRIPTION

A. Classrooms/Studios (Quantity – 5) See drawings for device quantities.
   1. Provide a single-channel ADA-compliant infrared assistive listening system used to meet ADA requirements and language translation.
   2. Provide 1080P video projectors on a fixed mount with a lens selected to fill the projection screen. Projector shall mounted to the deck above the drop ceiling grid. See floor plan for locations.
   3. Provide 16:10, 137” diagonal, electrically operated projection screens, wall flush mounted but concealed in the ceiling when not in use. The bottom of the image shall be 48” above the floor.
   4. Provide short throw projection systems
   5. Provide a multi-format presentation switcher using HDBaseT technology with integrated 70v amplifier and control processor and separate touch panel.
   6. Provide a multimedia lectern with the following:
      a. Internal rackmount space sufficient to mount the required equipment
      b. Internal shelf for OFE computer
      c. Internal shelf for DVD-Blu-ray player
      d. External shelf for document camera
      e. Cable management through the core and in the top
      f. Integrated light
   7. Provide a Blu-ray player and document camera. It shall plug directly into DM switcher in the lectern.
   8. Provide a lectern mounted wired touch panel (power over Ethernet) to control all aspects of the audiovisual system.
   9. Provide a 18” gooseneck microphone at the lectern with cardioid elements and integrated mute switch
   10. Provide a 70v distributed audio systems with the following:
        a. 6.5” coaxial ceiling speakers mounted on tile bridge support (see drawings for quantity)
        b. 2 channel 70 volt amplifier
        c. 2 channel digitally encrypted wireless microphone system with one (each) single handheld and lavalier microphones on different channels

B. Team Rooms type 1 (Quantity - 6)
   1. Provide wall-mounted LCD displays with surface mounted HDBaseT connector plates for VGA. 3.5 mm audio and HDMI to the displays.

C. Team Rooms type 2 (Quantity - 1)
   1. A ceiling mounted projector system with 113” 16:10 screen and wireless HDMI gateway to the projector
   2. Provide a 70v distributed audio systems with the following:
        a. 6.5” coaxial ceiling speakers mounted on tile bridge support (see drawings for quantity)
        b. 2 channel 70 volt amplifier

D. Meeting Rooms (Quantity - 1)
   1. Provide wall-mounted 70” HD LCD display with a wireless HDMI gateway(s)
   2. Provide a 70v distributed audio systems with the following:
a. 6.5” coaxial ceiling speakers mounted on tile bridge support (see drawings for quantity)
b. 1 channel 70 volt amplifier

E. Training Room (Quantity 1)
1. Provide wall-mounted HD LCD display(s) with a wireless HDMI gateway(s)
2. Provide a 70v distributed audio systems with the following:
   a. 6.5” coaxial ceiling speakers mounted on tile bridge support (see drawings for quantity)
   b. 1 channel 70 volt amplifier

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by the following:

B. Video Systems
   1. LCD Displays: Samsung
   2. Projector: Panasonic PT-RZ770 or equal
   3. Short Throw Projector: Epson Brightlink Pro 1460Ui or equal
   4. Screen: Draper Access V. Surface- TecVision XH900X.
   5. Document Camera: Elmo PX10 or equal
   6. Blu-ray Player: Denon

C. Audio Systems
   1. Ceiling Speakers: QSC AC-C6T or equal
   2. Amplifier: QSC CMS series or equal
   3. Digital Signal Processing: QSC Core series
   4. Wireless Microphone System: Shure QLXD series
   5. Assistive Listening System: Listen Technologies LT-800-072 TX and LR-4200-072 RX(s)

D. Signal Distribution and Processing
   1. Crestron DM Series
   2. HDMI Gateway: Mersive Solstice

E. Control Systems
   1. Processor: Crestron CP3-N
   2. Touch Panel: Crestron TSW-760

F. Mounts
   1. LCD Display: Chief
   2. Ceiling Projector: Chief

G. Furniture
   1. Lectern: Euro Design Systems

CABLE TYPES & ACCEPTED MANUFACTURERS/MODELS

VIDEO
| **RF Riser (Plenum)** | Liberty RG11-P-CATV |
| **RF Drop (Plenum)** | Liberty RG6-P-CATV |
| **Baseband (Plenum)** | Liberty RGB5C-SD-PLN |
| **RGBHV (Plenum)** | Liberty RGB5C-PLN |
| **RGBHV-Video-(4) Audio – Control (Plenum)** | Liberty AVC-18-PLN |
| **RG59 (Plenum)** | Liberty-RG59-CCTV-PL--BLK |
| **DVI-D (non-Plenum)** | Extron DVID DL Pro/x |
| **HDMI (Plenum)** | Liberty P-HDM-M |
| **CAT 6A STP (non-Plenum)** | Extron DM-CBL-ULTRA-P |

**AUDIO**

| **Mic/Line Level (non-Plenum)** | Liberty 22-2P-SIAM-EZ |
| **Digital Audio (non-Plenum)** | Liberty 24-1P-DIG-AUDIO-BLK |
| **Speaker Level, 8 ohm (run>20 feet Non-Plenum)** | Liberty 12-2C |
| **Speaker Level, 8 ohm (run>100 feet Plenum)** | Liberty 12-2C-P |
| **Speaker Level, 70v (Plenum)** | Liberty 14-2C-PP |
| **Control** | | |
| **4 Conductor (Plenum)** | Liberty 22/18-1PSH/2C-P |

**DATA**

| **CAT 6A (Plenum)** | Liberty 24-4P-P-L5-EN-BLK |
| **CAT 6A** | Liberty 24-4P-P-L6-EN-BLU |
| **50 ohm Antenna Cable. Plenum** | Liberty RG58-CMP-WHT |

Other Cable types are to be submitted to the Consultant for approval.

---

**PART 3 - EXECUTION**

3.01 **GENERAL**

A. Work shall be installed in neat, workmanlike manner only by competent and experienced workers. All equipment shall be installed to comply with manufacturer’s written instruction. Complete work in conformance to applicable federal, municipal and local codes.

B. Coordinate the entire installation throughout the construction team, including the Owner’s telecommunications systems contractor.

C. Certify device boxes are level when installed.

D. Manufacturer’s Instructions:
1. Comply with manufacturer’s product data, including product technical bulletins, product catalog installation instructions, and product carton instructions for installation.

2. Maintain jobsite file of Material Safety Data Sheets (MSDS) for each product delivered to jobsite packaged with an MSDS.

3.02 WIRING METHOD

A. Install cabling through conduits or sleeves. Use existing conduit paths where available. Provide pull string for future cable installation in any communications conduit 2” I.D. or larger during cable installation.

B. Provide grommets through knockouts prior to placing cable. Provide insulation bushings on conduits and sleeves prior to placement of cable.

C. Penetrations: Seal all rated partition penetrations with a fire stop system acceptable to the Authority Having Jurisdiction. Use specified fire rated wiring device or seal conduits with removable sealant.

D. Provide modular connectors and specified faceplate type at wall locations.

E. Provide 1/4” scale shop drawings of any atypical installation prior to installation.

F. Service cable shall be of sufficient length that all rack mounted equipment should be able to be removed from the front of the rack halfway without disconnecting any cables. On floor and wall boxes, plates should be able to be pulled entirely out of the box and laid on a surface for access to the rear connectors without disconnecting any cables.

3.03 LABELING

A. Label cables installed as part of this work using the specified labels. Affix labels at each end of cable. Additionally, affix labels to inter-building cables as they pass through pull boxes and underground vaults.

B. Provide white labels with black lettering when labeling faceplates and termination hardware.

C. All labeling to be machine generated (Brother P-Touch, Panduit, Brady, ink-jet or laser printer).

D. Add labels to the equipment racks bearing serial numbers of that equipment for which the serial numbers are not readily viewable when mounted.

3.04 TESTING

A. Test equipment: Use testing equipment and methods acceptable to the manufacturer of the connectivity hardware. Include the following procedures.

B. Test all audio, video, RF, wireless and remote control systems for compliance with the functional requirements and Performance Standards.
C. Configure, provision and align equipment for optimum performance and to meet the manufacturer's published specifications.

D. Prepare and maintain documentation of performance tests, including dates performed, numerical values of established equipment settings, for reference during the System Acceptance Tests. Submit final results prior to scheduling Final Acceptance Tests Manual.

E. Audio Systems
   1. Audio Test Signal Paths: Verify signal flow and performance from source inputs (for microphones, recorders, DVD and CD units, etc.) through distribution amps, signal processors, mixers, switchers, etc., to signal destinations
   2. Hum and Noise Level:
      a. Measure the hum and noise levels of the overall system for each microphone input channel and line-level input channel.
      b. Adjust gain controls for optimum signal-to-noise ratio so that full amplifier output will be achieved with 0 dBM at a line-level input.
      c. Terminate line-level inputs with shielded resistors of 150 and 600 ohms, respectively, for these measurements.
      d. Disconnect the loudspeaker lines and terminate the power-amplifier outputs with power resistors for these measurements. The value of the load resistor shall be within 5% of the nominal load impedance of the amplifier under test. The power rating of the resistor shall equal the power rating of the amplifier.
      e. Using the oscilloscope on the output of each audio amplifier with the loudspeakers connected, check to ensure that output is free from spurious oscillation and radio-frequency pickup, in the absence of audio input signal and when the system is driven to full output at 100 Hz. Apply slow sine-wave sweep from 50 Hz to 5 kHz at a level of 6 dB below rated power-amplifier output voltage. Listen carefully for buzzes, rattles and objectionable distortion.

3. Video Systems
   a. Video Test Signal Paths: Verify signal flow and performance from source inputs (for cameras, recorders, DVDs, CATV receivers, input plates etc.) through distribution amps, signal processors, switchers, etc., to signal destinations.
   b. Video Test Signal Paths: Verify signal flow and performance from source inputs (for cameras, recorders, DVDs, CATV receivers, input plates etc.) through distribution amps, signal processors, switchers, etc., to signal destinations.
   c. Test all progressive scan inputs at a variety of common resolutions, up to the native resolution of the display device.

4. Projection Systems
   a. Using a calibration tool, measure luminance at five points along the screen – the center and all 4 corners- in foot candles and compare to the calculations for the projector’s specified light output and the screen’s published gain properties.
   b. Using the ANSI lumens test pattern, verify the projected image has at least 8 discreet levels of grey, from 15% White to 100% White.
c. Using a SMPTE color-bar test pattern with the blue filter enabled, calibrate Color so that projected image reflects alternating identical blue and black vertical bars.

d. Using the on-screen menu, set the projector’s color temperature at 6,500 degrees Kelvin

5. Control Systems
   a. Verify functions and operations for each device
   b. Verify operations for each user interface (touch button or panel).
   c. Provide one printed copy of test results bound in a 3-ring binder. Organize in ascending outlet ID order. Provide electronic copy of test results for review and approval. Provide software (if other than MS Office) required to properly view and print the test results. If proprietary software is required, provide one copy of user license with the test results.

3.05 DOCUMENTATION

   A. Provide all test results on the cabling as specified in Paragraph 3.04.

   B. Provide Record Drawings showing device outlet number (label ID). Architect will provide AutoCAD backgrounds for Contractor’s use in developing Record Drawings. Provide electronic copies on CD and two bond copies (1/8” scale). The device outlet number Record Drawings specified in this paragraph are in addition to Record Drawings, shop drawings, or any other Drawings required by Division 0 and Division 1.

3.06 CLEANUP AND REPAIR

   A. Upon completion of the work, remove refuse and rubbish from and about the premises, and shall leave the relevant areas and equipment clean and in an operational state. Repair damage caused to the premises by the installation activities, at no cost to the Owner.

3.07 PROTECTION OF WORK

   A. During the installation, and up to the date of final acceptance, protect finished and unfinished work against damage and loss. In the event of such damage or loss, replace or repair such work at no cost to the Owner.

END OF SECTION
SECTION 28 10 00
ACCESS CONTROL AND ALARM MONITORING SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Materials, equipment, fabrication, installation and tests in conformity with applicable Codes and Authorities Having Jurisdiction for the following:
   1. A complete Access Control and Alarm Monitoring System as described in the Specifications and as shown in detail on the Drawings.
   2. Complete system is defined as all labor and materials required to complete the Work described herein and on the Drawings including but not limited to: conduit, raceways, cables, cabling, connectors, risers, network interfaces, back boxes, card readers, cards, request to exit sensors, motion detectors, alarm contacts, controllers, specific alarm panels, access control panels, power supplies, transformers, UPS’s, printers, intercoms, intercom head-end equipment and programming, telephones, programming, labor, hard drives, software upgrades, license upgrades, software support licenses and access control head end software. Also provide and install required communication equipment and gear, phone line monitoring, power filtering, enclosures, tamper switches, latches and locks, mounts, housings, stands, interfaces to new and existing electrified door hardware, interfaces to automatic door operators and interfaces to equipment furnished by others.
   3. Products, equipment, materials, systems, assemblies, software and accessories as specified herein define the minimum standards. Specifications and Drawings do not show or list every item, accessory, fastener, bracket, sub-assembly and appurtenance to be provided. When an item not shown or listed is clearly necessary for proper installation, operation and functioning of the equipment and systems the Security Contractor shall provide, install, test and certify the item at no increase in Contract price.
   4. The existing Software House Access Control Server will communicate to the access control field panels and associated intrusion detection panels via a network connection over the Owner’s LAN/WAN. Security Contractor shall coordinate IP addresses, LAN drops, network connectivity and bandwidth allocation and usage with the Owner’s IT department.
   5. Provide all software, hardware, and programming for installation, connection and operation of the new security system equipment.
   6. Provide installation, testing, adjustment and initial programming for all equipment and systems.
   7. Security Contractor is responsible for fully implementing the functions described in the Specifications and shown on the Drawings.
   8. Coordinate all telephone and data network connections, programming, and requirements with Owner’s IT department / contractor.
   10. Provide training to the Owner in the operation, programming, adjustment, servicing, troubleshooting and repair of all systems.
11. Provide proposed naming conventions for equipment listed under this Section to the Owner 30 days prior to programming.

1.02 RELATED SECTIONS

A. Conduit, wire and cable installations performed under this Division shall comply with all applicable sections of the Local Building Codes, California Electrical Code and electrical requirements.

B. Coordinate door hardware with the hardware contractor.

C. Coordinate all electrical power and conduit requirements with the electrical contractor and the Owner. All security systems shall be on an emergency power branch circuit.

D. Coordinate video alarm activation and camera call-up features with the CCTV System specified in Section 28 20 00.

1.03 REFERENCES

A. Published specifications, standards, tests and codes and recommended standards of trade, industry or governmental organizations apply to Work in this Section including:
1. ADA – Title 3 of the Americans with Disabilities Act
2. ASCII – American Standard Code for Information Interchange
3. ASTM – American Society for Testing and Materials
4. CCR – Titles 19 and 24 of the California Code of Regulations
5. EIA – Electronic Industry Association
6. NEMA – National Electrical Manufacturers’ Association
7. UL – Underwriters Laboratories, Inc.

B. Electronic devices radiating "RF" energy shall comply with Federal Communication Commission regulations, particularly Part Fifteen, and shall meet minimum Class "B" requirements. Provide FCC certificate numbers indicating that the FCC has approved the products.

1.04 QUALITY ASSURANCE

A. A nationally recognized test laboratory shall list all equipment supplied whenever such testing is applicable.

B. All equipment and accessories shall be the product of a manufacturer regularly engaged in its manufacture.

C. All items of a given type shall be the products of the same manufacturer.

D. All items shall be of the latest technology; no discontinued models or products are acceptable.

E. No “beta” products will be accepted.

F. The manufacturer, or their authorized representative, shall confirm that within one hundred miles of the Project site there is an established agency which:
1. Stocks a full compliment of parts of the same manufacturer and model as installed per these Specifications.
2. Offers service during normal working hours as well as emergency service on all equipment to be furnished.
3. Will supply parts and service without delay and at reasonable cost.

G. Security Contractor shall be certified for asbestos work (if applicable to this Project).

H. Security Contractor shall be capable of performing service or maintenance work on the specified systems. Security Contractor’s lead technician shall be factory-certified by the security system manufacturer.

I. Security Contractor must be a Software House authorized dealer. The Security Contractor shall possess all required Contractor's licenses.

1.05 SUBMITTALS

A. Submit the following to the Architect and Security Consultant in electronic PDF format for approval prior to commencement of Work:
   1. Manufacturer's name, brand name, exact part number, options, accessories and catalog references for all equipment supplied. Indicate UL Listings for all system components.
   2. Complete wiring diagrams for all components, including cable types and quantities, routings, floor plans indicating device locations, conduit sizes, point-to-point termination and riser diagrams.
   3. Proposed construction schedule detailing the timeline for the Project. Obtain Owner approval of finalized construction schedule before the commencement of Work. When Work is performed in a sensitive area or an area occupied with ongoing business activities coordinate with the Owner and the affected department's representative to determine the best time to perform the Work required. Sequencing and scheduling of this type is normal on a Project of this nature and shall not be considered grounds for claims of delay.
   4. Master Device Legend Table on the Drawings that identifies the symbols used for all devices including mounting heights, back box requirements, part and model numbers, operating voltages (if applicable), wire and cabling requirements, wire label verbiage, and panel termination points.
   5. Fully dimensioned Drawings including plan views, elevations and details of all Security Operations Centers, equipment rooms and closets, consoles, controllers, racks, enclosures, control panels, and fabricated equipment showing locations of all major components including mounting details. These Drawings shall be 1/4 inch scale at a minimum.
   7. Service agency information, including address, phone number and website of nearest agency meeting the requirements of Article 1.4 F of this Section.
   8. Written certification letter from each manufacturer affirming that Security Contractor is approved for systems installation and service for all systems in this Section.
   9. Proposed training program, including name and qualifications of trainer(s), schedule of training, curricula, and written training materials.
   10. Submit for review and approval proposed programming, including device names and descriptions, timings, and sequence of operations at least 30 days prior to the
actual programming of the system.

11. Provide a combined submittal with equipment as specified in section 28 20 00.

B. Submittals must be complete. All security system submittals shall be in a similar format for ease of review. The Architect and Security Consultant reserve the right to reject any submittals determined to be incomplete. Rejection of submittals for failure to meet these requirements shall not be considered grounds for claims of delay.

C. Partial or “Typical” Drawings will not be accepted. All Drawings shall be done in AutoCAD 2017.

1.06 SUBSTITUTIONS

A. All equipment, products and systems shall conform to the Specifications and Drawings. No substitute equipment, products or systems may be used unless previously accepted in writing by the Owner, Architect and Security Consultant.

B. Equipment, products and systems for which substitutions will not be accepted are clearly indicated in the paragraph where specified. Substitution requests for equipment, products and systems so noted will be rejected without review.

C. Manufacturers listed as acceptable are normally engaged in the type of Work specified. The listing of equipment and product part numbers or particular types of systems by specific manufacturers is to establish a minimum standard for the performance, quality, and parameters of the equipment, products and systems specified. The Owner, Architect and Security Consultant must approve all substitutions in writing prior to any substitute equipment, products or systems being incorporated into this Project.

D. Any substitute equipment, products or systems incorporated into this Project without prior written approval from the Owner, Architect and Security Consultant will be considered defective and shall be rejected. Rejected items shall be promptly removed from the Project and replaced with the specified materials and equipment by the Security Contractor at no increase in Contract price and shall not be considered grounds for claims of delay.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship equipment in original packages to prevent damage or entry of foreign matter. All handling shall be in accordance with manufacturer recommendations. Provide protective covering during construction.

B. Replace, at no increase in Contract price, all equipment, products or systems damaged during shipping, handling, distribution, storage and installation or during subsequent construction when directed by the Owner or Architect and Security Consultant.

C. Products delivered to the Project site and stored, whether on the Project site or in an off-site location previously approved in writing by the Owner, shall be protected from dust, dirt, and foreign matter. All equipment is to be protected from dents, bumps, and scratching.

1.08 WARRANTY
A. Security Contractor and manufacturer guarantee installation, equipment, software, software support and all parts and labor for one year from written notification of acceptance by the Owner.

B. The installing Security Contractor shall provide, upon notification of a problem, a field service technician to correct the problem within twenty-four hours of notification.

C. At least sixty days prior to expiration of warranty Security Contractor shall perform complete functional system testing as described in Article 3.5 of this Section. Warranty shall not expire and shall remain in full force and effect until all identified problems are corrected and system is fully functional and completely operational.

D. At least sixty days prior to expiration of warranty Security Contractor shall provide maintenance contract proposals for a third year of service for each system to the Owner.
   1. Warranty shall include provisions of Article 3.4 C of this Section.

PART 2 - PRODUCTS

2.01 ACCESS CONTROL AND ALARM MONITORING SYSTEM PRODUCTS

A. System Specifications
   1. The access control equipment shall be Software House, no substitutions. The Diablo Valley Community College District currently has a Software House access control system. The Manufacturer's catalog and system numbers of equipment listed in the Specifications indicate type, capability and functions of the equipment required and represent the minimum acceptable standards.
   2. The Security Contractor shall program all necessary information for the access control system and CCTV system on the District's existing Software House Access Control Server. Programming for this Project includes but is not limited to access control panel programming, CCTV interface and site specific user information.
      a. The Security Contractor will perform all necessary tests of the systems and monitor systems activity and functionality during the Security Upgrade.
   3. Altronix power supplies shall power the access control panels and peripheral devices. Altronix power supplies shall power all electrified door hardware not requiring specific or individual power supplies.
      a. Provide battery back-up sufficient for four hours standby at maximum rated load for all power supplies.
      b. Security Contractor to provide a separate enclosure for the batteries should the batteries not fit securely in the power supply enclosure “right-side-up”. Do not lay batteries on their side or end in order to fit them into the enclosure. Do not expose wiring between the power supplies and the batteries. Label all batteries to identify devices powered.

B. System Software
   1. The Security Contractor shall provide and install any and all licenses required to fully support all devices shown on drawings.

C. Access Control Panels
   1. The security contractor shall provide and install provide and install a 16 door
software house IStar pro 128mb acp, with two ACM boards, and altronix AL1012ULX16CB 12v and AL1024ULX16CB 24v power supplies in a locking enclosure capable of housing all ACP components. Head end equipment shall support all field devices as shown on the drawings and configured as shown in the riser diagram. Provide all equipment for a fully functional system. Program ACP on existing Diablo Valley Community College Software House access control server.

D. Card Reader Door Devices
1. Security Contractor to provide and install Software House RM1-4000 card readers.
   a. The card reader shall communicate in a Wiegand protocol interface and be compatible with all standard access control systems.

2. Security Contractor to provide and install Bosch DS160 request-to-exit motion detector and TP160 mounting plate at all card reader door locations. No substitutions will be accepted.
   a. Request-to-exit motion detectors shall be wired normally closed with a 5-state supervision resistor installed at the End-of-Line device.
   b. At exterior locations provide a request to exit as part of the hardware assembly and connect it to the access control system.

3. Security Contractor to provide and install Interlogic 1076C concealed alarm contact in door frames and concealed magnets in door leafs at all card reader door locations.
   a. Contact shall consist of 1 SPDT contact in one switch.
   b. Contact shall have an alarm gap distance of no more than 1/2 inch.
   c. Door contacts shall be wired normally closed with a 5-state supervision resistor installed at the End-of-Line device.
   d. Contact color shall be provided to best match door frame finish.
   e. Contact shall not be larger than 3/4 inch.
   f. Pairs of doors shall have alarm contacts on each door leaf and the alarm contacts will be wired in a series circuit.

4. Security Contractor to provide switched lock power to electrified locks and strikes.
   a. Locks shall unlock when 24 VDC power is applied for a “Fail Secure” operation.

E. Power Supplies
1. Security Contractor to provide and install Altronix AL1024ULXP16CB and AL1012ULXP16CB power supplies with factory-installed power distribution modules to power all access control panels, electrically controlled door locks and door strikes, request to exits and peripheral devices at locations as shown on the Drawings. No substitutions will be accepted.
   a. Power supply/charger units shall have factory-applied Class 2 Rated label.
   b. Install each individual lock, request to exit and peripheral device on a separate output of the power distribution module.
   c. Provide sufficient quantity of power supplies with factory-installed power distribution modules to permit simultaneous continuous-duty activation of all door locks with an additional minimum 20 percent capacity on each supply.
   d. Calculate voltage drop to locks and size lock control wiring to provide proper
lock operation.
e. Provide battery back-up sufficient for four hours standby plus twenty-five activations for all DC locks.
f. Monitor the AC fail relay for power failure and the low battery relay for low battery. These alarms shall have individual monitor points on the access control system.
g. Furnish and install noise suppression diodes on all locks as close as possible to the lock and at the control relay coil.
h. Furnish and install tamper switches on each power supply enclosure. Tamper switches shall be wired to monitor points on the access control panel and shall be configured for twenty-four hour alarm supervision.
i. Provide and install cabinet locks on each power supply enclosure. Security Contractor to provide locks keyed alike for all power supply enclosures.
j. All power supplies shall have a machine generated label on the exterior of the power supply in plain sight identifying the enclosure and equipment served, i.e. 24VDC SOFTWARE HOUSE POWER SUPPLY.

F. Electrified Locks and Hardware
1. Electrified locks, strikes, door hardware, “panic bar” exit devices and local electrified door hardware power supplies to be used in conjunction with card reader access doors shall be furnished and installed by the hardware contractor. The Security Contractor is responsible for all low voltage wiring and terminations to electrified locks, electrified door hardware and electric transfer hinge hardware.
   a. Sequencing, scheduling and coordinating with the hardware contractor and the Owner is the responsibility of the Security Contractor.
   b. Programming, interfacing and testing of systems integration of controlled hardware is the responsibility of the Security Contractor.
   c. Pulling, installing, dressing, terminating and connecting wiring to the electrified locks and hardware is the responsibility of the Security Contractor.
   d. Security Contractor shall coordinate with electrical contractor for 120VAC power and interface of controlled hardware with the Fire Alarm Control Panel (FACP).
   e. All electrified locks and hardware used in conjunction with card reader access doors shall be “Fail Secure” unless otherwise noted or required by law to be “Fail Safe”.

G. Alarm Contacts
1. Security Contractor to provide and install GE Sentrol 1076 C concealed alarm contact in door frames and concealed magnets in door leafs at locations shown on the Drawings including all doors with card readers or exit alarms.
   a. Each motion detector shall be a distinct alarm zone on the intrusion alarm system.
   b. Contact shall consist of 1 SPDT contacts in one switch.
   c. Contact shall have an alarm gap distance of no more than 1/2 inch.
   d. Door contacts shall be wired normally closed with a 5-state supervision resistor installed at the End-of-Line device.
   e. Contact color shall be provided to best match door frame finish.
   f. Contact shall not be larger than 3/4 inch.
   g. Pairs of doors shall have alarm contacts on each door leaf and the alarm contacts will be wired in a series circuit.

H. Motion Detectors
1. Security Contractor to provide and install Takex PA-7100E radial motion detector with BU-7000 flush mount attachment at locations shown on the Drawings. No substitutions will be accepted.
   a. Each motion detector shall be a distinct alarm zone on the intrusion alarm system.
   b. Each detector shall have an EOL resistor at the detector.
   c. Resistors shall be installed at the EOL as a pre-manufactured device with values to match the system installed. Resistor pack shall have screw terminals and be manufactured by GRI.
   d. Provide a machine generated label with the device number in programming on the device so it is visible while standing beneath the detector.

I. End of Line Resistors
   1. Security contractor to provide and install resistor packs for all alarm initiating devices with the value as required by the system they are connected to. All devices shall have a normally closed circuit and alarm on open. Ensure 5 state zone monitoring of all points where permitted by the system they are connected to.

J. Labels
   1. All labels for all cabling, power supplies, AC power cords and any connection to the security equipment shall be clearly labeled to identify the connected device or purpose. Labels shall be vinyl wrap with clear over lay so as not to become unraveled and shall not be made of plastic. Labels shall be placed as close to the wire termination point as possible and not placed on equipment that can be removed or replaced.
   2. All labels for security equipment shall be clearly applied so as to easily identify the device or system served. Provide labels for all mounted and installed equipment including the exterior of enclosures, power supplies, UPS and other equipment. Labels shall be vinyl and not made of plastic.

K. Tamper Switches
   1. Security contractor to provide and install magnetic tamper switches on all enclosures, and power supplies.
      a. Provide and install GE Sentrol 1285T surface mounted alarm contact for tamper switches on hinged security enclosure doors.
      b. Where multiple enclosures are provided for the same sub-system, provide a series circuit between all tampers as a single input to the system.

L. Intrusion Alarm Panel
   1. Security Contractor to provide and install Bosch D9412GV4 Control Panel, enclosure, power supply, auxiliary power battery back-up and D1255 Command Center Keypad Arming Station at locations shown on the Drawings. No substitutions will be accepted.
      a. Security Contractor shall program the intrusion alarm panel to send alarm signals to the District’s Central Monitoring Station.
      b. Security Contractor to perform all programming of the intrusion detection system to ensure a complete and working system to the Owner’s satisfaction.
      c. Coordinate and test all zones with the central monitoring station.
      d. Security Contractor to install Bosch intrusion detection system in a locked enclosure with a tamper switch.
      e. Security Contractor to supply and install D8004 transformer cover for the
Bosch intrusion detection system D1640 transformer.

f. Security Contractor to coordinate the installation of network and telephone line connections inside the Bosch enclosure.

g. Security Contractor to provide and program telephone line supervision hardware and function.

h. Security Contractor to install the arming station keypads at locations shown on the Drawings.

i. Contractor to provide a machine generated label on the exterior of all power supplies and transformers identifying the equipment served.

j. On the interior of the enclosure door list all phone, account and IP address and numbers using a machine generated label.

2. Security Contractor to provide and install B426 Network Interface Module for the Bosch intrusion detection system.

   a. Primary means of communication shall be via dial-up voice line to the Central Monitoring Station. Secondary or backup communications shall be via network connection to the Software House access Control system. Coordinate telephone line and network connections and locations with the Owner and program accordingly. Security Contractor has responsibility for setting up the account with the offsite monitoring company in time to meet the construction schedule.

   b. Security Contractor to provide coordination and programming to integrate the Software House access control system with the Bosch intrusion detection system.

3. Security Contractor to provide and install Bosch D8128D OctoPOPIT Eight Point Expanders for individual device input wiring.

   a. Security Contractor to provide sufficient input points to monitor all field devices and ensure a minimum of 10 percent spare input points.

   b. Initiating circuits shall be wired normally closed with a 5-state supervision resistor installed at the End-of-Line device.

   c. Resistors shall be installed at the EOL as a pre-manufactured device with values to match the system installed. Resistor pack shall have screw terminals and be manufactured by GRI.

   d. Security Contractor to provide sufficient output points for all remote annunciation requirements and ensure a minimum of 10 percent spare output points.

2.02 WIRE AND CABLE

A. Wire and Cable Specifications

   1. Security Contractor shall follow the manufacturers' recommendation for cabling or the minimum requirements of the Specifications and Drawings, whichever provides for the most stringent requirements.

   2. Wire and cable sizes, number of conductors, shielding, or other data listed in this Specification or shown on Drawings are a guide to the correct product required to achieve a working system and represent the minimum acceptable equipment.

   3. Cables are to be shielded as necessary to preclude any outside noise or interference from entering the cable and degrading system performance. All cables shall be U.L. Listed, and appropriate for the application.

   4. Use proper grounding practices to eliminate shorts, ground faults, ground loops, RF interference, voltage fluctuations, foreign voltages and open circuits.

   5. Coordinate with the Owner’s IT department for telephone line requirements and location for off-site monitoring. Provide RJ31X phone jacks for telephone system
6. Cables run underground, under slab, or in slab shall be installed in conduit and rated for direct-burial application. Cables above hard ceiling or inaccessible areas shall be installed in conduit. Stub up conduits from within walls into accessible spaces.

7. All cables run in environmental air handling spaces shall be plenum rated. Provide proper J-hooks for cables not run in conduit. Cables not required to be in conduit shall be run along but not in Tel/Data cable trays.

8. All cables shall be run in unbroken lengths of 1000 feet or less. No coaxial or power cables less than 1000 feet shall be spliced. When cable cannot be run in unbroken lengths due to cable spool limitations, splices shall be made in junction boxes with terminal blocks or terminal strips and fork spade lugs. All splices and junction boxes shall be clearly marked on the “As-Built” Record Drawings.

9. All wire to wire splices not utilizing terminal blocks or terminal strips shall be done with dolphin style connectors and wrapped in electrical tape. Wires shall be individually stripped and then twisted together, crimped, and then neatly taped together to form the narrowest splice possible for ease of installation and removal, as well as overall protection of the splice. Where wires are not used or are extra trim the wires back to allow future use and then tape them with the used wiring for ease of removal.

10. All End-of-Line supervision resistors shall be installed at the individual protection devices, and not in the control panels.

11. All 24VAC power cabling shall be of stranded construction. For connections requiring pressure captive connection, wire shall be solder tinned prior to insertion into pressure connectors.

12. Wiring shall be grouped and harnessed to facilitate access to all equipment, as well as maintenance and replacement of equipment.

13. All cable shall be labeled at origin and termination, referencing to a master legend schedule as shown on “As-Built” Record Drawings. Labeling and any splice locations shall be noted on “As-Built” Record Drawings. All labels shall be done using machine generated cable tags in the “flagged” position. Hand written labels are not acceptable.

14. Cabling shall be sized and installed according to California Electric Code requirements.

15. Any cabling or raceway exposed to weather shall be rated for that use.

16. Stub up conduits from outlets into weather shall be rated for that use. Mixing of security low voltage cables with Tel/Data cables will not be permitted. Utilize approved clips or mounting to securely mount security cable to the rack framework or hangers.

17. Cable not run with the cable tray shall be run along the wall using J-hook hangers. Hangers shall be sufficient to properly support cable.

B. Cabling shall be West Penn, Belden, Windy City Wire or approved equal.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Systems shall be complete and operational in all respects.
B. Security Contractor shall furnish and install all equipment for all building security systems.

C. Wiring and conduit shown on Drawings represents a minimum requirement. Security Contractor shall furnish and install all wiring recommended by submitted system manufacturers for optimum system performance at no increase in Contract price.

D. All wall, floor, and ceiling penetrations, regardless of the fire rating of the partition, must be properly sleeved with conduit and properly sealed using approved fire stopping materials and sealants.

E. Connect power to security systems as required and coordinate with the electrical contractor.

F. All security equipment, junction boxes, and terminal cans installed in public accessible areas shall be installed utilizing tamper proof mounting hardware. Provide a minimum of two driver bits or hand tools to the Owner’s representative for each type and size of security fastener provided.

G. Provide seismic restraint for all equipment, including equipment racks and consoles.

H. Security Contractor shall provide the Owner with a minimum of four complete sets of keys for all equipment installed in this Project prior to the close of the Project. All keys relating to the security systems shall be kept separate from the building systems and delivered to the Owner’s representative.

3.02 RECORD DRAWINGS

A. Maintain a complete set of “As-Built” Record Drawings updated with mark-ups inserted as the Work is performed. As Work is installed carefully mark on “As-Built” Record Drawings in colored pencil the correct location of all Work including depth of underground runs and concealed Work with their dimensions from clearly identified points on permanent buildings, fixtures, walls, or walks. Wiring diagrams, risers and details shall be included.

B. Upon completion of the Project transfer hand-drawn information to CAD Drawings then copy updated CAD Drawings onto compact disc and submit to the Owner, Architect and Security Consultant. No hand-drawn “As-Built” Record Drawings will be accepted.

C. “As-Built” Record Drawings shall be provided in four plotted sets as well as one set of CAD Drawings on compact disc to the Owner, Architect and Security Consultant. One additional complete half-size plotted set shall remain on the Project site in folders secured inside the electronic racks.

D. Contractor shall input a map of the building into the Software House software with the devices installed as part of this project. The map shall accurately reflect device locations and building layout and correlate to the system programming. The Building Map shall be of high quality with clear devices and text utilize the as-built device drawings as the basis for this map.

3.03 TRAINING
A. Training shall be by engineers or technicians highly skilled in the systems installed and factory trained and certified by the manufacturer as qualified to train in the particular systems.

B. Provide a minimum of 5 hours of scheduled training for the equipment furnished under this Section, including programming, operation, service, and maintenance.

C. Training shall be conducted at dates and times directed by the Owner. Training shall be provided for all security staff personnel.

D. Documentation of completion of training shall be delivered to and verified by the Owner prior to release of retainage.

3.04 PROGRAMMING

A. Security Contractor shall provide initial programming for all applicable systems. Security Contractor programming shall include, but not be limited to:
   1. English-language description of each alarm location.
   2. Programming of the head-end equipment.
   3. Coordination and programming of all alarm initiated control signals to the CCTV system for camera call-up and video recording alarms. Cameras located next to or in the area of an alarm shall be programmed to generate a motion triggered event on the Software House system.

B. Submit to the Owner, Architect and Security Consultant for review and approval proposed programming, including device names and descriptions, zones, timings, alarms and sequence of operations prior to programming.

C. Upon Owner's request, the Security Contractor shall reprogram each system one time during the warranty period at no increase in Contract price. At the time of such programming the Security Contractor shall update the system software to the most recent version available at the time at no increase in Contract price.

3.05 TESTS AND REPORTS

A. Perform systems tests using personnel who have attended a manufacturer's training school for installation and testing of the systems as described above. Perform testing with the test instruments as required by the manufacturer; testing by means other than the manufacturer's procedures will not be acceptable unless agreed to by the Owner, Architect, Security Consultant and manufacturer.

B. The Security Contractor shall test the following system and document these tests for the Owner, Architect and Security Consultant prior to final commissioning;
   1. Card Readers
      a. The card reader LED is red when the door is secure.
      b. The card reader LED is solid green when the door is placed in an unlocked mode.
      c. The card reader beeps and the LED flashes green and when a valid card is presented.
      d. The card reader will read the access cards as specified for this Project when presented to the reader at the range as specified by the manufacturer.
      e. The card reader produces an offline signal on the system when power or communication to the reader is lost.
f. The card reader will produce alarms from denied access and expired cards on the system.

2. Door Alarm Contact
   a. The contact is free from faults and trouble conditions.
   b. The contact produces a door forced open alarm on the system when the door is opened without a valid card read or with a key.
   c. The contact produces a door held open alarm on the system 15 seconds for perimeter doors and 30 seconds for interior doors after the door is opened.

3. Request-to-Exit
   a. The request-to-exit is free from faults and trouble conditions.
   b. The request-to-exit shunts the door alarm contact upon activation from a user exiting the room.

4. Electrified Hardware
   a. The electrified hardware unlocks when a valid card is presented to the corresponding reader.
   b. The electrified hardware unlocks when an unlock command is sent from the system.
   c. The electrified hardware stays unlocked for a maximum of 10 seconds on perimeter doors and 20 seconds on interior doors after a valid card is presented. Failure to open the door within the stated time will result in relocking of the door.
   d. The electrified hardware re-locks after a valid card is presented and the door is opened.

5. Alarm Contacts
   a. The alarm contact is free from faults and trouble conditions.
   b. The alarm contact generates an alarm on the system when the associated door is opened within the specified gap distance.
   c. The alarm contact generates a reset or clear alarm on the system when the door is closed and latched.
   d. The alarm contact does not produce alarms on the system when the door is shut and moved back and forth inside the frame.

C. Upon completion of the installation of the security systems Security Contractor shall submit written reports including but not limited to the following information:
   1. A complete list of all equipment installed including serial numbers of major components.
   2. Certification that all equipment is properly installed, programmed, functional, 100 percent operational and conforms to Specifications and Drawings.
   3. Test reports of all zones, devices, and equipment.
   4. Test technician's name, company and date of test.

D. Following review of the test report by the Architect and Security Consultant, Security Contractor shall perform a functional test of all security system equipment in the presence of the Owner, Architect and Security Consultant. Test shall include performance tests of each device, switch, control unit, power supply, battery standby unit, monitor panel, controller, printer, and all other equipment and material required by the Specifications and Drawings. The Security Contractor shall be responsible for all additional costs to the Owner, Architect and Security Consultant if retesting is required. At a minimum, perform tests to demonstrate that:
   1. All systems are free from shorts, ground faults, ground loops, RF interference, voltage fluctuations, foreign voltages and open circuits.
   2. Each alarm-initiating device consistently functions as specified and produces the
specified alarm actions.
3. Systems operate properly on battery backup.
4. The system is operable under specified trouble conditions.
5. An abnormal condition of any circuit or device required to be electrically supervised will result in activating the specified trouble or tamper alarm signal.
6. All software functions properly as specified, and all equipment is fully programmed. The Security Contractor shall be responsible for programming the systems with English-language descriptors as specified by the Owner.
7. Test all functions and interfaces of system.

E. Security Contractor to provide testing reports using the Owner format for all devices installed under this scope of work.

3.06 IT REQUIREMENTS

A. IT Department / Contractor Shall:
1. Provide network drops in the security equipment locations as shown on the Drawings. Where possible drops shall be provided in the security enclosure.

B. Provide static IP addresses, 100/full speed, gateways and subnet mask information for the access control system to communicate to the Software House Access Control Server.

END OF SECTION
SECTION 28 20 00
CLOSED CIRCUIT TELEVISION SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Materials, equipment, fabrication, installation and tests in conformity with applicable Codes and Authorities Having Jurisdiction for the following:
   1. A complete Closed Circuit Television Surveillance System (CCTV) as described in the Specifications and as shown in detail on the Drawings.
   2. Complete system is defined as all labor and materials required to complete the Work described herein and on the Drawings including but not limited to: conduit, raceways, cables, cabling, connectors, riser blocks, patch panels, patch cables, network interfaces, access control system interfaces and programming, back boxes, IP Network Cameras using PoE, analog cameras, camera lenses, monitors, Network Video Recorders, digital video encoders, PoE switches, programming, power supplies, UPS's, transformers, power line monitoring, power filtering, enclosures, tamper switches, latches and locks, mounts, arms, housings, stands, relay interfaces and equipment cabinets.
   3. Products, equipment, materials, systems, assemblies, software and accessories as specified herein define the minimum standards whether provided new or upgraded. Locations, quantities and scope of work at individual device and equipment locations are shown in detail on the Security Electronics Drawings.
   4. Specifications and Drawings do not show or list every item, accessory, sub-assembly and appurtenance to be provided. When an item not shown or listed is necessary for proper installation, operation and functioning of the equipment and systems the Security Contractor shall provide, install, test and certify the item at no increase in Contract price.
   5. Provide installation, testing, adjustment and initial programming for all equipment and systems.
   6. Security Contractor is responsible for fully implementing the functions described in the Specifications and shown on the Drawings.
   7. Coordinate all LAN/WAN connections required for digital video transmission and viewing with the Owner’s IT department.
   8. Provide training to the Owner in the operation, programming, adjustment, servicing, troubleshooting and repair of this system.
   9. Provide proposed naming conventions for equipment listed under this Section to the Owner 30 days prior to programming.

1.02 RELATED SECTIONS

A. Conduit, wire and cable installations performed under this Division shall comply with all applicable sections of the Local Building Codes, California Electrical Code and electrical requirements.

B. Coordinate video alarm activation and camera call-up features with the Access Control and Alarm Monitoring System specified in Section 28 10 00.
C. Coordinate all electrical power and conduit requirements with the electrical contractor and the Owner. All security systems shall be on an emergency power branch circuit.

D. Coordinate all required cabling, PoE switches, and connections for CCTV cameras with DVC IT Department and or IT Contractor.

1.03 REFERENCES

A. Published specifications, standards, tests and codes and recommended standards of trade, industry or governmental organizations apply to Work in this Section including:
   1. ADA – Title 3 of the Americans with Disabilities Act
   2. ASCII – American Standard Code for Information Interchange
   3. ASTM – American Society for Testing and Materials
   4. CCR – Titles 19 and 24 of the California Code of Regulations
   5. EIA – Electronic Industry Association
   6. NEMA – National Electrical Manufacturers’ Association
   7. UL – Underwriters Laboratories, Inc.

B. Electronic devices radiating "RF" energy shall comply with Federal Communication Commission regulations, particularly Part Fifteen, and shall meet minimum Class "B" requirements. Provide FCC certificate numbers indicating that the FCC has approved the products.

1.04 QUALITY ASSURANCE

A. A nationally recognized test laboratory shall list all equipment supplied whenever such testing is applicable.

B. All equipment and accessories shall be the product of a manufacturer regularly engaged in its manufacture.

C. All items of a given type shall be the products of the same manufacturer.

D. All items shall be of the latest technology; no discontinued models or products are acceptable.

E. No “beta” products will be accepted.

F. The manufacturer, or their authorized representative, shall confirm that within one hundred miles of the Project site there is an established agency which:
   1. Stocks a full complement of parts of the same manufacturer and model as installed per these Specifications.
   2. Offers service during normal working hours as well as emergency service on all equipment to be furnished.
   3. Will supply parts and service without delay and at reasonable cost.

G. Security Contractor shall be capable of performing service or maintenance work on the specified systems. Security Contractor’s lead technician shall be factory-certified by the security system manufacturer.
H. Security Contractor must be a Software House authorized dealer. The Security Contractor shall possess all required Contractor's licenses.

1.05 SUBMITTALS

A. Submit the following to the Architect and Security Consultant in electronic PDF format for approval prior to commencement of Work:

1. Manufacturer's name, brand name, exact part number, options, accessories and catalog references for all equipment supplied. Indicate UL Listings for all system components.

2. Complete wiring diagrams for all components, including cable types and quantities, routings, floor plans indicating device locations, conduit sizes, point-to-point termination and riser diagrams.

3. Proposed construction schedule detailing the timeline for the Project. Obtain Owner approval of finalized construction schedule before the commencement of Work. When Work is performed in a sensitive area or an area occupied with ongoing business activities coordinate with the Owner and the affected department's representative to determine the best time to perform the Work required. Sequencing and scheduling of this type is normal on a Project of this nature and shall not be considered grounds for claims of delay.

4. Master Device Legend Table on the Drawings that identifies the symbols used for all devices including mounting heights, back box requirements, part and model numbers, operating voltages (if applicable), wire and cabling requirements, wire label verbiage, and panel termination points.

5. Fully dimensioned Drawings including plan views, elevations and details of all Security Operations Centers, equipment rooms and closets, consoles, controllers, racks, enclosures, control panels, and fabricated equipment showing locations of all major components including mounting details. These Drawings shall be 1/4 inch scale at a minimum.


7. Service agency information, including address, phone number and website of nearest agency meeting the requirements of Article 1.4 F of this Section.

8. Written certification letter from each manufacturer affirming that Security Contractor is approved for systems installation and service for all systems in this Section.

9. Proposed training program, including name and qualifications of trainer(s), schedule of training, curricula, and written training materials.

10. Submit for review and approval proposed programming, including device names and descriptions, timings, and sequence of operations at least 30 days prior to the actual programming of the system.

11. Provide a combined submittal with equipment as specified in section 28 10 00.

B. Submittals must be complete. All security system submittals shall be in a similar format for ease of review. The Architect and Security Consultant reserve the right to reject any submittals determined to be incomplete. Rejection of submittals for failure to meet these requirements shall not be considered grounds for claims of delay.

C. Partial or “Typical” Drawings will not be accepted. All Drawings shall be done in AutoCAD 2013.
1.06 SUBSTITUTIONS

A. All equipment, products and systems shall conform to the Specifications and Drawings. No substitute equipment, products or systems may be used unless previously accepted in writing by the Owner, Architect and Security Consultant.

B. Equipment, products and systems for which substitutions will not be accepted are clearly indicated in the paragraph where specified. Substitution requests for equipment, products and systems so noted will be rejected without review.

C. Manufacturers listed as acceptable are normally engaged in the type of Work specified. The listing of equipment and product part numbers or particular types of systems by specific manufacturers is to establish a minimum standard for the performance, quality, and parameters of the equipment, products and systems specified. The Owner, Architect and Security Consultant must approve all substitutions in writing prior to any substitute equipment, products or systems being incorporated into this Project.

D. Any substitute equipment, products or systems incorporated into this Project without prior written approval from the Owner, Architect and Security Consultant will be considered defective and shall be rejected. Rejected items shall be promptly removed from the Project and replaced with the specified materials and equipment by the Security Contractor at no increase in Contract price and shall not be considered grounds for claims of delay.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship equipment in original packages to prevent damage or entry of foreign matter. All handling shall be in accordance with manufacturer recommendations. Provide protective covering during construction.

B. Replace, at no increase in Contract price, all equipment, products or systems damaged during shipping, handling, distribution, storage and installation or during subsequent construction when directed by the Owner, Architect or Security Consultant.

C. Products delivered to the Project site and stored, whether on the Project site or in an off-site location previously approved in writing by the Owner, shall be protected from dust, dirt, and foreign matter. All equipment is to be protected from dents, bumps, and scratching.

1.08 WARRANTY

A. Security Contractor and manufacturer guarantee installation, equipment, software, software support and all parts and labor for one year from written notification of acceptance by the Owner.

B. The installing Security Contractor shall provide, upon notification of a problem, a field service technician to correct the problem within twenty-four hours of notification.

C. At least sixty days prior to expiration of warranty Security Contractor shall perform complete functional system testing as described in Article 3.5 of this Section. Warranty
shall not expire and shall remain in full force and effect until all identified problems are corrected and system is fully functional and completely operational.

D. At least sixty days prior to expiration of warranty provide maintenance contract proposals for a third year of service for each system to Owner.
1. Warranty shall include provisions of Article 3.4 C of this Section.

PART 2 - PRODUCTS

2.01 CLOSED CIRCUIT TELEVISION SYSTEM

A. System Specifications
1. The existing CCTV head-end equipment is Salient Systems. The Security Contractor shall verify camera licensing and provide and program into the CCTV head-end sufficient camera licenses to support all cameras being installed as part of this project.
2. Security Contractor will program all information on the Software House Access Control Server necessary to interface the access control system with the Network Video Recorder and CCTV system.
3. Programming for this Project includes but is not limited to Network Video Recorders, access control system, CCTV interface, cameras and site specific user information.
   a. The Security Contractor will perform all necessary tests of the systems and monitor systems activity and functionality during the installation.

B. CCTV Cameras
1. Security Contractor to provide and install interior dome cameras with integrated lens and recessed ceiling mount as shown on the Drawings. No substitutions will be accepted.
   a. IP Network Cameras shall be Axis P3225-LV Fixed Dome IP Network Camera.
   b. Provide 2.8 – 10 mm lens with auto iris.
   c. IP Network Cameras shall use H.264 technology to send compressed data streams over the IP Network.
   d. IP Network Cameras shall utilize PoE power supplied over the IP Network cable. Do not connect DC power to the IP Network Camera at the same time as PoE power, as damage to the camera will result.
   e. Secure all IP Network Cameras as appropriate to structural requirements and construction conditions using tamper-proof mounting hardware.
   f. IP Network Camera housings installed on ceilings shall have attachments to building structure independent of ceiling, fire sprinkler, conduit, or other system supports.
   g. All Axis remote camera log in shall be set using the Owner’s standards for these devices.
   h. Cameras shall provide a clear and focused picture that is level with the field of view.

2. Security Contractor to provide and install exterior dome cameras, pendant housing, arm and integrated lens as shown on the Drawings. No substitutions will be accepted.
a. IP Network Cameras shall be Axis P3365-VE with Pendant Dome and T91D61 wall mount arm Fixed Dome IP Network Camera.
b. Provide 2.5 – 6 mm lens with auto iris and day night functions.
c. IP Network Cameras shall use H.264 technology to send compressed data streams over the IP Network.
d. IP Network Cameras shall utilize PoE power supplied over the IP Network cable. Do not connect DC power to the IP Network Camera at the same time as PoE power, as damage to the camera will result.
e. Secure all IP Network Cameras as appropriate to structural requirements and construction conditions using tamper-proof mounting hardware.
f. IP Network Camera housings installed on ceilings shall have attachments to building structure independent of ceiling, fire sprinkler, conduit, or other system supports.
g. All Axis remote camera log in shall be set using the Owner’s standards for these devices.
h. Cameras shall provide a clear and focused picture that is level with the field of view.

3. Security Contractor shall replace or adjust lenses at no increase in Contract price to Owner if necessary to obtain proper field of view.
4. Coordinate the installation of cameras with the Owner and obtain approval of camera locations prior to installation.
5. Provide a machine generated label on the bottom of each camera housing with the camera number as shown in programming. The label shall not include the full camera name.

C. Labels
1. All labels for all cabling, power supplies, AC power cords and any connection to the security equipment shall be clearly labeled to identify the connected device or purpose. Labels shall be vinyl wrap with clear over lay so as not to become unraveled and shall not be made of plastic. Labels shall be placed as close to the wire termination point as possible and not placed on equipment that can be removed or replaced.
2. All labels for security equipment shall be clearly applied so as to easily identify the device or system served. Provide labels for all mounted and installed equipment including the exterior of enclosures, power supplies, UPS and other equipment. Labels shall be vinyl and not made of plastic.

2.02 WIRE AND CABLE

A. Wire and Cable Specifications
1. Security Contractor shall follow the manufacturers’ recommendation for cabling or the minimum requirements of the Specifications and Drawings, whichever provides for the most stringent requirements.
2. Wire and cable sizes, number of conductors, shielding, or other data listed in this Specification or shown on Drawings are a guide to the correct product required to achieve a working system and represent the minimum acceptable equipment.
3. Cables are to be shielded as necessary to preclude any outside noise or interference from entering the cable and degrading system performance. All cables shall be U.L. Listed, and appropriate for the application.
4. Use proper grounding practices to eliminate shorts, ground faults, ground loops, RF interference, voltage fluctuations, foreign voltages and open circuits.

5. CCTV video and control cables run underground, under slab, or in slab shall be installed in conduit and rated for direct-burial application. Cables above hard ceiling or inaccessible areas shall be installed in conduit. Stub up conduits from within walls into accessible spaces.

6. All cables run in environmental air handling spaces shall be plenum rated. Provide proper J-hooks for cables not run in conduit. Cables not required to be in conduit shall be run along but not in Tel/Data cable trays.

7. All coaxial and power cable shall be run in unbroken lengths of 1000 feet or less. No coaxial or power cables less than 1000 feet shall be spliced. When cable cannot be run in unbroken lengths due to cable spool limitations, coax splices shall be made in junction boxes with crimp-type BNC connectors, power cable splices shall made using solder and tape. For coaxial cable the center conductor tip shall be a crimp-on style; the ferrule shall be a hexagonal crimp with a minimum ferrule length of 3/8 inch.

8. All 24VAC power cabling shall be of stranded construction. Terminal strips and fork spade lugs shall be utilized for all terminations. For connections requiring pressure captive connection on CCTV cameras, wire shall be solder tinned prior to insertion into pressure connectors.

9. Wiring shall be grouped and harnessed to facilitate access to all equipment, as well as maintenance and replacement of equipment.

10. All cable shall be labeled at origin and termination, referencing to a master legend schedule as shown on “As-Built” Record Drawings. Labeling and any splice locations shall be noted on “As-Built” Record Drawings.

11. All final labeling shall be with machine-generated printed labels, specifically made for cable labeling. No handwritten labels will be accepted.

12. Cabling shall be sized and installed according to California Electric Code requirements.

13. Any cabling or raceway exposed to weather shall be rated for that use.

B. Cabling shall be West Penn, Belden, Windy City Wire or approved equal.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Systems shall be complete and operational in all respects.

B. Security Contractor shall furnish and install all equipment and accessories as well as miscellaneous wire, cabling and conductors for all building CCTV Systems.

C. All security equipment such as enclosures, junction boxes and terminal cans installed in public accessible areas shall be installed utilizing tamper proof mounting hardware. Provide a minimum of 2 hand tools with driver bits to the Owner's representative for each type and size of security fastener provided.

D. Provide proper and adequate seismic restraint for all equipment including equipment racks, cabinets, and consoles.
3.02 RECORD DRAWINGS

A. Maintain a complete set of “As-Built” Record Drawings updated with mark-ups inserted as the Work is performed. As Work is installed carefully mark on “As-Built” Record Drawings in colored pencil the correct location of all Work including depth of underground runs and concealed Work with their dimensions from clearly identified points on permanent buildings, fixtures, walls, or walks. Wiring diagrams, risers and details shall be included.

B. Upon completion of the Project transfer hand-drawn information to CAD Drawings then copy updated CAD Drawings onto compact disc and submit to the Owner, Architect and Security Consultant. No hand-drawn “As-Built” Record Drawings will be accepted.

C. “As-Built” Record Drawings shall be provided in four plotted sets as well as one set of CAD Drawings on compact disc to the Owner, Architect and Security Consultant. One additional complete half-size plotted set shall remain on the Project site in folders secured inside the electronic racks.

3.03 TRAINING

A. Training shall be by engineers or technicians highly skilled in the systems and certified by manufacturer as qualified to train in the particular systems.

B. Provide a minimum of 5 hours training for the systems described in this Section.

C. Training shall be conducted at dates and times directed by the Owner. Training shall be provided for all security staff personnel, as directed by the Owner.

D. Documentation of completion of training shall be delivered to and verified by the Owner prior to release of retainage.

3.04 PROGRAMMING

A. Security Contractor shall provide initial programming for the CCTV system and all its components. Security Contractor programming shall include, but not be limited to:
   1. English-language description of each alarm and camera location.
   2. Camera locations and numbers for display on CCTV monitors.
   3. Select camera-recording sequences based on specific alarm inputs from the security system.
   4. Motion detection mapping or alarm inputs into the NVR to start, enhance, or otherwise mark the video data segment.

B. Submit for review and approval proposed programming, including device names and descriptions, timings, and sequence of operations at least 30 days prior to the actual programming of the system.

C. Contractor shall input a map of the building into the Software House software with the devices installed as part of this project. The map shall accurately reflect device locations and building layout and correlate to the system programming. The Building
Map shall be of high quality with clear devices and text utilize the as-built device drawings as the basis for this map.

3.05 TESTS AND REPORTS

A. Perform systems tests using personnel who have attended a manufacturer's training school for installation and testing of the systems as described above. Perform testing with the test instruments as required by the manufacturer; testing by means other than the manufacturer's procedures will not be acceptable unless agreed to by the Owner, Architect, Security Consultant and manufacturer.

B. Security Contractor shall perform the following tests on the system and document these tests for the Owner, Architect and Security Consultant.

1. Network Video Recorders (NVR)
   a. The NVR operates when connected 120VAC supply power.
   b. The NVR operated when connected to its associated UPS when 120VAC supply power is lost.
   c. The NVR shuts down properly when the shutdown command is received from its associated UPS.
   d. The NVR records and shows all of the cameras connected to it.
   e. The NVR stores recorded video data and allows the retrieval of stored video when requested from a workstation.
   f. The NVR shows clear and bright pictures form all associated cameras.
   g. The NVR produces a system alarm when any associated video image is lost.
   h. The NVR starts, operates and records properly when the unit is restarted from a power failure.

2. Cameras
   a. The camera produces a clear and focused picture.
   b. The camera adjusts properly between day and night lighting conditions.
   c. The camera produces a stable picture with no roll, flutter or ghosting.
   d. The camera produces a clear picture when supply power is returned from a power failure.

C. Upon completion of the installation of the CCTV systems Security Contractor shall submit written reports including but not limited to the following information:

1. A complete list of all equipment installed including serial numbers of major components.
2. Certification that all equipment is properly installed, programmed, functional, 100 percent operational and conforms to Specifications and Drawings.
3. Test reports of all devices and equipment.
4. Test technician’s name, company and date of test.

D. Following review of the test report by the Architect and Security Consultant, Security Contractor shall perform a functional test of all CCTV system equipment in the presence of the Owner, Architect and Security Consultant. Test shall include performance tests of each camera, all digital video server functions, and all other equipment and material required by the Specifications and Drawings. Security Contractor shall be responsible for all additional costs to the Owner, Architect and
Security Consultant if retesting is required. At a minimum, perform tests to demonstrate that:
1. All systems are free from shorts, ground faults, ground loops, RF interference, voltage fluctuations, foreign voltages and open circuits.
2. Each camera shall be positioned by Security Contractor to provide the video coverage of the protected area in accordance with the capabilities of the device.
3. Systems operate properly on battery backup.
4. All software functions properly as specified and all equipment is fully programmed. Security Contractor shall be responsible for programming system English-language descriptors as specified by the Owner.
5. Test all functions and interfaces of system.

E. The security contractor shall utilize the Owners Commission Checklist during testing documenting all devices installed under this section and their functionality.

3.06 IT REQUIREMENTS

A. IT Department / Contractor Shall:
1. Provide all internal data network communications equipment and PC workstations not specified in Part 2 – Products of this Section.
2. Provide network drops in the security equipment locations as shown on the Drawings.
3. Provide static IP addresses, 100/full speed, gateways, and subnet mask information for the CCTV system to communicate to the Software House Access Control Server and client workstations as shown on the Drawings.

B. Provide PoE ports on TR switches for all IP cameras as shown on the drawings.

END OF SECTION
SECTION 28 31 00

ANALOG ADDRESSABLE FIRE ALARM AND DETECTION SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Fire alarm system operation.
   2. Fire alarm equipment.
   3. Fire alarm wiring.

B. This is a bidder design system. Contact Authority Having Jurisdiction (AHJ) prior to bid to verify fire system requirements. Provide design compliant with codes as interpreted by AHJ.

C. Design and provide an integrated, analog addressable, monitoring and control system for a complete fire alarm system as described herein. The system includes, but is not limited to, control units, power supplies, digital alarm communicating transmitter, remote annunciators, initiating devices, notification appliances, and outputs for specified fire life safety and control functions. The system also includes batteries, relays, fire alarm termination cabinets, conduit, wiring, and other equipment for a complete and operating system.

D. Unit Prices: Provide unit pricing for the following pieces of equipment. The unit pricing will include complete installation of devices listed with 40 feet of cable, conduit, if required, connections, programming, battery capacity, and the like.
   1. Addition of manual pull station.
   2. Addition of rate-or-rise or fixed temperature heat detector.
   3. Addition of photoelectric or ionization smoke detector.
   4. Duct mounted ionization or photoelectric smoke detector.
   5. Magnetic door holder.
   6. Speaker.
   7. Audible/visible notification appliance.
   8. Visible notification appliance.
   9. Addressable relay with complete connection to item to be controlled or monitored.

1.02 SYSTEM DESCRIPTION

A. System Supervision: Provide electrically supervised, microprocessor-based system, with analog/addressable supervised two-wire Class B signaling line circuit and Class B notification circuit. Occurrence of single ground or open condition in initiating device, notification appliance, or signaling line circuit places circuit in "trouble" mode. Component or power supply failure places system in "trouble" mode. Fire sprinkler activation or duct-mounted smoke detector activation puts system in “supervisory” mode. Occurrence of single ground or open condition on alarm initiating circuit or on signaling circuit does not disable that circuit or control panel from transmitting "alarm." Each circuit includes individual supervisory and alarm function and is to be so
arranged that a fault condition in circuits will not affect the proper operation of other circuits.

B. Alarm Sequence of Operation: Activation of a manual fire alarm box, automatic fire detector, or fire extinguishing system causes system to enter “alarm” mode including the following operations:
1. Provide local English language annunciation of device location, address and condition, and audible and visual alarm signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible alarm signal, visual signal remains displayed until initiating alarm is cleared.
3. Transmit “alarm” signal to off-premises equipment, i.e., to the local fire department or Owner's selected vendor. Provide necessary connections to digital alarm communicator transmitter.
4. Activate fire alarm notification appliances.
5. Transmit signal to fire/smoke dampers.
6. Transmit signal to initiate shutdown of air handling equipment.
7. Transmit signal to release fire doors.
8. Transmit signals to elevator control equipment to initiate elevator recall and shunt trip.
9. Transmit signal to building access/security system.

C. Supervisory Sequence of Operation: Fire sprinkler tamper switch activation or duct-mounted smoke detector activation causes system to enter "supervisory" mode including the following operations:
1. Provide local English language annunciation of device location, address and condition, and audible and visual supervisory signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible supervisory signal, visual signal remains displayed until initiating supervisory is cleared.
3. Transmit "supervisory" signal to off-premises equipment.

D. Trouble Sequence of Operation: System trouble, including single ground or open of supervised circuit, or power or system failure, causes system to enter "trouble" mode including the following operations:
1. Provide local English language annunciation of device location, address and condition, and audible and visual trouble signal at control panel and remote annunciators.
2. Provide manual "acknowledge" function at control panel and remote annunciators to silence audible trouble signal, visual signal remains displayed until initiating trouble is cleared.
3. Transmit "trouble" signal to off-premises equipment.

E. System Reset: Key-accessible control function returns the system to normal, non-alarm state, if initiating circuits have cleared. Reset to be located on both the main fire alarm control panel and the remote annunciators.
F. Lamp Test: Manual "lamp test" function causes the annunciation lamps to illuminate at fire alarm control and remote annunciator panels. Provide "lamp test" function at each annunciator panel.

G. Addressing: Provide each initiating device with its own discrete analog address.

H. Power Requirements:
1. The control panel receives 120VAC via a dedicated circuit per NFPA requirements.
2. Loss of normal and emergency power automatically causes the system to transfer to battery power. Indicate battery power operation by a yellow lamp and audible annunciation at the control panel and remote annunciator panels. Upon return of 120VAC power, unit recharges batteries to full capacity and maintains battery on float charge.
3. Provide storage batteries of sufficient capacity to operate the fire alarm system under normal supervisory condition for 24 hours and operate alarm signals for 15 minutes at the end of the standby period. Provide trickle charge adequate capacity to maintain the battery fully charged with automatic rate charge. Provide batteries in a locking cabinet manufactured for the purpose. Do not install cabinets or equipment below the battery cabinet. Do not locate battery and charging system cabinets in ceiling space.

1.03 SUBMITTALS
A. Submit shop drawings and product data in accordance with Division 01.

B. A maximum of two submittal reviews will be performed by the Engineer. Compensate additional time and material to the Engineer based on their published fees for additional reviews.

C. Equipment submittals must include the following:
1. Complete descriptive data (cut sheets) including UL listing, FM approval (for the specified application) for system components.
2. Provide Shop drawings to include the following:
   a. A symbol key with device catalog number, description, dimensions, back box size and mounting requirements.
   b. Detailed riser diagram.
   c. Device address and notification appliance circuit number with end-of-line device.
   d. Battery calculations for each battery backed fire alarm control unit.
   e. Voltage drop calculations for each notification appliance circuit, indicating conductor run length and size. 10 percent voltage drop maximum.
   f. Complete sequence of operation.
   g. Point to point wiring indicating the quantity and gauge of the conductors and size of conduit/raceway used.
   h. Wiring connection diagrams for components being connected to the system and interfaces to associated equipment.

D. Submit manufacturer's installation instructions.
E. Submit complete product data sheets and shop drawings to local AHJ, for approval, prior to construction.

F. Submit, prior to final acceptance, a letter confirming that inspections have been completed and the system is installed and functioning in accordance with the Specifications. Include manufacturer representative's certification of installation and letter of warranty.

G. Operation and Maintenance Manuals: Provide manuals containing cut sheets, manufacturer's operation and maintenance manual, troubleshooting guide, operating instructions, spare parts list, program printout, and data file on CD-ROM, 1 year warranty agreement including parts and labor, and professional Record Drawings. Warranty period begins upon the date of final acceptance.

1.04 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Installation subject to inspection and approval of federal, state and local authorities.
   2. Equipment: UL listed FM approved.
   3. Contact AHJ prior to bid and provide required fire alarm and detection devices and components as required by adopted codes as interpreted by AHJ.

B. Reference Standards:
   8. UL 864 Listing.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Furnish equipment specified in this Section by one manufacturer: Siemens MXLV, XLSV or approved equal.

2.02 MATERIALS

A. Control panel:
   1. Multiprocessor Based: Configurable as an analog/addressable, point identified system.
   2. System will be capable of displaying the analog value of each smoke detector, the address and condition of fire alarm monitoring points.
   3. CPU continuously monitors the communications and data processing cycles of the microprocessor. On CPU failure the system generates an audible and visual trouble signal on the control panel and remote annunciators.
4. House the CPU in the fire alarm cabinet with sufficient space to allow maximum system expansion and to enclose the alphanumeric display.

5. Retain basic life safety software in field programmable non-volatile memory. Provide the CPU with a capacity of a minimum of 100 addressable points.

6. The system is multichanneled. Each channel operates independently. Faults on one channel not impede operation of the other.

7. Equip the CPU with software to provide a control-by-event feature, whereby the receipt of an alarm point is programmed to operate the control points within the system. Provide control-by-event actions for life safety functions in a programmable non-volatile memory. CPU software programming for control of systems defined in this Section is installed as a part of this Section. Reprogram the support system prior to acceptance, if required by Owner.

8. System is capable of addressing and operating smoke detectors, manual pull stations, open contact devices and addressable auxiliary control relays on the same communication loop.

9. Program Software:
   a. The field configuration program provides the programmable operating instructions for the system. Store the resident program in non-volatile memory.
   b. Perform the programming at the location of the fire alarm control panel. Program the system without shutting the system down. Programming is done off line. Update and maintain a hard copy and a CD-ROM copy of the program at the site. Make system programming software available to Owner, at an additional cost, allowing the user to reprogram system points, add system points, add or change point descriptions and update the data file.
   c. Programmed control point activation includes selective control of HVAC, door holder release, elevator recall, system equipment monitoring, and fire safety and auxiliary functions.
   d. Devices meet criterion specified under materials.
   e. Verification and display of sensitivity of each addressable smoke detector can be read using the operating software. Replace devices with readings outside of the allowed value at time of system check out.

10. Control Panel Display Modules: Provide keyboard display module 80-character backlit LCD. Each alarm/trouble condition appears in English language with the description and location of the alarm/supervisory/trouble. The alarm/supervisory/trouble may be acknowledged, silenced and the system reset from the control panel or the remote annunciator(s).

11. Power Supply: Provide power supply(s), adequate to serve control panel modules, remote annunciators, addressable devices, notification appliances, and other connected devices.

12. Digital Alarm Communicator Transmitter (DACT): Electrically supervised, capable of transmitting alarm, supervisory and trouble signals over telephone lines to off-premises receiver. Signal transmitter interfaces fully with receiver station of local fire department or Owner's selected vendor. Verify requirements and provide call sequence and message as directed by Owner and the AHJ.

13. Auxiliary Relays: Provide sufficient SPDT auxiliary relay contacts for each function in this portion of the Specifications and for equipment interconnections required under electrical and mechanical specifications.
14. Auxiliary Switches: Provide auxiliary equipment control switches with labeled status indicating lights for each switch.

B. Emergency Voice/Alarm Communications System Panel.
1. UL 864 listed.
2. Provide the fire protective signaling system circuits in accordance with Style Y for Notification Appliance Circuits (NAC). Open condition in circuit will cause trouble indication at control panel.
3. LED indicators for power trouble, ground trouble, and signal trouble in each NAC. Also, LED indicators for manual evacuation status, clear status, and "ready to talk" status for manual microphone paging.
4. Selectable audio tones (at least four different tone patterns) and voice message generation via digital recorded messages (either Owner supplied, from professionally recorded tapes or a manufacturer provided library).
5. Operator controls at panel include manual evacuation (alarm signal from momentary switch activation), manual clear from momentary switch activation, local microphone manual paging, remote microphone manual paging option.
6. Capable of receiving alarm signal from host panel notification appliance circuit.
7. Includes audio amplifier with a minimum capacity of 50 watt.
8. Built-in spoken diagnostic system testing program, permitting testing of individual speakers by one unassisted person.

C. Addressable Initiating Devices:
2. Fixed Temperature Heat Detectors: Rated 135F or 190F as noted on Drawings or required by space use. Provide off white low profile detectors.
3. Rate-of-Rise and Fixed Temperature Heat Detectors: Responding to 15F temperature rise per minute and to 135F fixed temperature as noted on Drawings or required by space use. Provide off white low profile detectors.
5. Ionization Type Analog Detector: Analog/addressable dual chamber 360 degree smoke entry, visual latching operation indicator, insect screen, panel adjustable sensitivity, test switch, tamper resistant and solid state voltage regulation.
6. Duct-Mounted Analog Smoke Detectors: Analog addressable, combination of ionization and photoelectric types, auxiliary relay contacts rated at 5 amps each at 120VAC. Duct sampling tubes extending width of duct, visual indication of detector actuation, direct housing mount. Detector powered from control panel, power on indicator light. Detector rated for air velocity, humidity, and temperature of duct. Provide with a remote LED/test switch.
7. Flame Detector: Encapsulated solid state electronic circuitry with auxiliary contacts. Visual alarm light, 3 second time delay, open area ultra violet 6 second response to 12-inch diameter hydrocarbon fire when viewed head-on from 30 feet. No response to sunlight or artificial light sources. Provide each detector with an addressable module.
8. Addressable Control Module: Signaling line circuit interface module that connects to notification appliance circuits and provides system control outputs. Module powered from control panel.

9. Addressable Monitor Module: Signaling line circuit interface module that connects to initiating devices and initiating device circuits. Module powered from control panel.

10. Remote Switches: Provide remote control/indication and test switches for system or equipment testing or control accompanied by English language labeled indicator lamps, i.e. for duct-mounted smoke detectors, projected beam type smoke detector, and the like.

11. Water Flow and Pressure Alarm Switches: Verify requirements, locations, and quantities with sprinkler design. Switches are provided by Division 15, wired by Division 16, unless specifically noted otherwise. Provide each switch with an addressable module.

12. Supervisory Pressure and Tamper Switches: Verify requirements, locations, and quantities with sprinkler design. Switches are provided by Division 15, wired by Division 16, unless specifically noted otherwise. Provide each switch with an addressable module.

13. Projected Beam Type Smoke Detector: Infrared emitter and receiver, adjustable reception threshold, micro processor self adjusting compensation for optic contamination, acrylic anti fog infrared filter, green power indicating LED, red alarm LED, and yellow trouble LED. Voltage and RF suppression, compensating circuitry for vibration and temporary obscuration. Auxiliary contacts. Provide each detector with an addressable module and a remote LED/test switch.

14. Wire Guards: Chrome steel guard. Provide where device is subject to abuse and where required by AHJ. Submit original, color, data cut sheets for approval by Architect.

15. Single/Multiple Station Smoke Alarm: 120VAC photoelectric smoke alarm/detector with 9VDC battery backup as an auxiliary power source in the event of an electrical failure. Include 90dB piezo solid-state, nonlatching horn. Temporal 3 evacuation sounding device. Tandem connection up to 12 units. Three-position test switch.

16. Single/Multiple Station Smoke Alarm with Strobe: 120VAC photoelectric smoke alarm/detector with 9VDC battery backup. Include 90dB piezo solid-state, nonlatching horn and 177 candela strobe. Add Alternate: Coordinate with Campus for Temporal 3 evacuation sounding device. Tandem connection up to six units. Three-position test switch.

D. Annunciators:

1. Alphanumeric Remote Annunciator with Controls: Back lit LCD alphanumeric annunciator 80 characters long. Provide under locking cover a test switch, alarm and trouble buzzer, buzzer silence switch and buzzer silence message and reset switch, flush mount with finished cover, vandal-resistant UV stabilized Lexan (or approved) overlay and required modules, control panel, etc., to drive annunciator. Self-contained, suitable for wet location where located exterior. Verify location with AHJ before installation.

2. Provide framed floor plan of facility adjacent to the annunciator panel identifying room names/numbers, device/addresses or fire zone number and listing as utilized on the annunciator panel, as required by local AHJ. Check with the local fire department for size and approved mounting location.
E. Door Hold-Opens/Closers, Elevator Recall, Fire/Smoke Damper Control, and Fire Safety and Auxiliary Functions:
1. Magnetic door holders. Provide smoke detection and addressable control relays to release magnetic hold open devices. Verify requirements and quantities prior to bidding.
   a. Magnetic hold open/closers installed by door hardware supplier. Division 16 provides power and control conduit, wiring, boxes and terminations to power devices and interface devices to fire alarm system.
   b. Hold door open until signaled by addressable relay module. When actuated, the device will release door to close. Doors release automatically on power failure.
2. Provide elevator recall smoke detectors, addressable control relays, and connection to elevator equipment per NFPA 72 and as required by the AHJ.
3. Provide elevator shunt trip heat detectors, addressable control relays, addressable monitor relay for shunt trip power, and connection to elevator equipment per NFPA 72 and as required by the AHJ.
4. Provide fire/smoke damper control/monitoring. Provide required smoke detectors, relays, wiring, and the like. Provide spot type smoke detector(s), listed for releasing service, and install within 5 feet of the dampers per the CBC or as required by the AHJ. Verify requirements, locations and quantities with Division 15 prior to bidding.

F. Notification Appliances:
1. Speakers: Flush wall mount, white finish. Insect-proof 4-inch multitap to 1/4, 1/2, 1, and 2 watts with back box and trim grill. State of California fire marshal listed. Provide speaker capable of transmitting tone or voice. Trim finish as directed by Architect. Provide with integral ADA and UL 1971 approved strobe light as required by AHJ. Candela rating as required per space used.
2. Speaker/Strobe Appliances: Flush wall mount, white finish. Provide speaker capable of transmitting tone or voice. Provide with integral ANSI 117.1 and UL 1971 approved strobe light. Candela rating as required per space used.
3. Audible/Visible Appliances (Horn/Strobes): Flush wall mount, white finish. Provide horn-strobes that meet the latest requirements of NFPA 72, ANSI 117.1 and UL standard 1971. Candela rating as required per space used.
4. Visible Notification Appliances (Strobes): Flush wall mount, white finish. The strobes will meet or exceed the latest requirements of NFPA 72, ANSI 117.1, and UL standard 1971. Candela rating as required per space used.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Obtain approval of system design from AHJ prior to installation. Do not begin installation without approval from AHJ and submittal review comments from Engineer.

B. Terminate fire alarm conductors in control and annunciator panels on terminal strips. Connect wiring neatly and secure to cabinet with nylon cable straps. Set up termination of cabling so that sections of the system may be isolated or shorted out for servicing. Maximum of two conductors under each terminal strip connection.
C. From fire alarm controlled relays, make connection to motor controls and related equipment as required for fan system control. Provide relays UL listed for the purpose.

D. Wiring:
1. In accordance with manufacturer's instructions, provide wiring, conduit and outlet boxes required for the erection of a complete system as described herein, as shown on Drawings, and as required by AHJ.
2. Provide wiring to meet the requirements of national, state and local electrical codes. Provide color coded wiring as recommended and specified by the fire alarm and detection system manufacturer. Minimum signaling line circuit and initiating device circuit wire size: AWG 18. Minimum notification appliance circuit wire size: AWG 14, or as approved by the Engineer. Test wiring free from ground faults and short circuits.
3. Provide complete conduit system for wiring. Provide Type FPL power-limited fire alarm cable. Provide Type FPL power-limited fire alarm cable when run open or in raceway, Type FPLR power-limited fire alarm cable when run is from floor to floor or in a vertical run in a shaft (install raceway where passing through a floor to a height of 7 feet above the floor) and Type FPLP power-limited cable when wiring is in ducts or plenum space.
4. Provide final connections between equipment and the wiring system approved by manufacturer.
5. At junction boxes and termination points, provide identification tags on wires and cables.

E. Duct-Mounted Smoke Detectors:
1. Provide duct-mounted smoke detectors on air systems with air quantities of 2000 cfm or more. Coordinate with Division 15.
2. Install duct-mounted smoke detector(s) on supply or return side of air duct. Coordinate with campus for final location.
3. Provide control wiring from duct-mounted detector auxiliary relay contacts to air handling equipment controller. Connect to controller so that when duct-mounted smoke detector is activated, the air handling equipment is shut down.
4. Provide duct-mounted smoke detectors rated for air velocity, temperature, and humidity of duct. Verify quantities, locations, and requirements with Division 15 Drawings and mechanical system installer.
5. Where duct-mounted smoke detectors are mounted in inaccessible building void spaces provide access hatch. Provide access hatch with fire rating equivalent to rating of wall, ceiling, or shaft being penetrated.

F. Fire/Smoke Dampers and Smoke Dampers:
1. Connect control and power wiring to dampers per manufacturer's instructions.
2. Verify quantities, location and requirements of dampers with Division 15 Drawings and Specifications, and mechanical system installer.
3. For each fan unit serving fire/smoke dampers and smoke/dampers with associated duct-mounted smoke detectors, provide current sensing switch with 8-amp, 250-volt rated relay contacts (Hawkeye 740 series or approved) for cutting power to fire/smoke dampers when fan unit shuts down.
4. If damper is installed within a duct, provide smoke detector within 5 feet of damper with no air inlets or outlets between the damper and detector.
5. If damper is installed within an unducted opening, provide smoke detector located within a 5-foot horizontal radius of the damper to control the damper.

6. Provide control wiring, transformers and power connections for an operable damper and detection system.

3.02 FIELD QUALITY CONTROL

A. Upon completion of the installation, subject the system to operational tests and when necessary corrections have been accomplished, advise Architect who will schedule a final inspection test with the Owner. Ensure the connections to the fire alarm system have been in service for at least 10 days of trouble/alarm free operation prior to the final inspection. Furnish instruments, labor and materials required for the tests and a qualified technician to conduct the tests. Correct deficiencies found at no cost and retest system as necessary, prior to final acceptance. Tests include the following:

1. Operation of each signal initiating device (smoke detectors, heat detectors, pull stations, fire/smoke rated doors, process and facilities control sequences).

2. Operation of each notification appliance (alarm horn and alarm strobe).

3. Operation of features of the system under normal operation.

4. Operation of supervisory features of the system.

5. Operation of features of the systems on standby power with primary power off.

6. Documentation by download of control panel memory.

B. Upon completion of the installation of fire alarm equipment, provide to Architect a signed, written statement substantially in the form as follows: "The undersigned having been engaged as the Contractor on the facility confirms that the fire alarm equipment was installed in accordance with the Drawings, Specifications, wiring diagrams, instructions, directions provided by manufacturer, and requirements of the governing authorities."

3.03 EQUIPMENT DEMONSTRATION AND PERSONNEL TRAINING

A. At the direction of Architect the equipment supplier of the system will provide factory trained representative to demonstrate the operation of the fire alarm system equipment and to instruct the Owner's personnel in its operation. Provide names and date of instruction prior to final acceptance.

3.04 OPERATION AND MAINTENANCE MANUALS

A. Provide three sets of manuals to the Architect prior to final acceptance. Provide manuals containing professional developed Record Drawings, battery type and battery calculations, spare parts list, operating procedures, troubleshooting guide, program printout, data file on CD-ROM and a 1 year warranty agreement including parts and labor. Warranty period begins upon the date of final acceptance.

END OF SECTION
SECTION 28 31 11
DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Work under this section consists of all engineering, installation labor, materials, equipment, programming, services, permits, fees and transportation necessary for, and/or reasonably incidental to, the construction and completion in working order of the work specified herein.

B. Work includes, but is not limited to the following:
   1. Complete system design, engineering, testing and final acceptance by Owner and Authority having jurisdiction.
   2. Life safety fire alarm detection and signaling system.
   3. Plan check approval.
   4. Furnishing and installation of equipment and devices.
   5. Wiring in Conduit and connections.
   6. Interface with elevator controls.
   7. Programming, testing per NFPA 72, cleaning, adjusting of completed work.
   8. Wiring diagrams, shop drawings, equipment data.
   9. Complete warranty for five years. Proposal for subsequent maintenance contract including service, testing and repair or replacement.
  10. All work and material for complete and operable systems as indicated or specified.
  11. As constructed record drawings.
  12. Permits, inspections, fees.
  13. Identification and instruction in writing.
  14. Coordination with existing conditions and work of other trades.
  15. Furnishing of special back boxes for installation under electrical section.
  16. Extending 120 or 240 volt power from electrical panelboard, coordinating and updating load schedules with Owner.

C. Section Includes:
   1. Fire-alarm control unit.
   3. System smoke detectors.
   4. Air-sampling smoke detectors.
   5. Non-system smoke detectors.
   6. Heat detectors.
   8. Device guards.
9. Firefighters' two-way telephone communication service.
10. Firefighters' smoke-control station.
15. Digital alarm communicator transmitter.
17. Network communications.

D. Related Requirements:
   1. Section 28 05 13 “Conductors and Cables for Electronic Safety and Security” for cables and conductors for fire-alarm systems.
   2. Section 28 05 44 “Sleeves and Sleeve Seals for Electronic Safety and Security Pathways and Cabling”.

1.03 DEFINITIONS

A. EMT: Electrical Metallic Tubing.
B. FACP: Fire Alarm Control Panel.
C. HLI: High Level Interface.
E. PC: Personal computer.
F. VESDA: Very Early Smoke-Detection Apparatus.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.
   1. Include construction details, material descriptions, dimensions, profiles, and finishes.
   2. Include rated capacities, operating characteristics, and electrical characteristics.
B. Product Samples: For each device provide product sample for color and product review.
C. Shop Drawings: For fire-alarm system.
   1. Comply with recommendations and requirements in the “Documentation” section of the “Fundamentals” chapter in NFPA 72.
   2. Include plans, elevations, sections, details, and attachments to other work.
   3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
   4. Detail assembly and support requirements.
   5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
   a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
   b. Show field wiring required for HVAC unit shutdown on alarm.
   c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters’ control system.
   d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters’ smoke-evacuation system.
   e. Locate detectors according to manufacturer’s written recommendations.
   f. Show air-sampling detector pipe routing.
13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
15. Extend 120 volt power from electrical panelboard, coordinating and updating load schedules with Owner.

D. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
   a. Trained and certified by manufacturer in fire-alarm system design.
   b. NICET-certified, fire-alarm technician; Level III minimum.
   c. Licensed or certified by authorities having jurisdiction.

E. For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Include in the Fire Alarm System submittal all the following information submitted as a complete package for review by the inspection agency. The contractor may submit to Architect concurrently if prior written approval for concurrent submission is obtained from the Architect. Approval by the authority having jurisdiction does not constitute acceptance by the Architect for device locations. Submit within 30 working days of award of contract. Incremental submittals at 50%, 90% and 100% completion are acceptable if proposed scope and schedule for each submittal is accepted by the Architect. Proposed scope must be submitted within 10 working days of award of contract.
1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.
4. Prepare complete plans, risers, wiring diagrams, and installation drawings, coordinated with the work of other trades, for the fire alarm system stamped by a registered engineer where required by the inspecting agencies.
5. Plans shall be prepared under the supervision of a qualified technician who is experienced with the type of work specified herein and is currently certified by the National Institute for Certification in Engineering Technologies (NICET) as an engineering technician with minimum level III certification.
6. Obtain governing agency approval for fire alarm system after submitting shop drawings and before installing any portion of the system.
7. Obtain and incorporate Architectural and Owners review comments and submit modifications to authority having jurisdiction for final approval, bring any conflicts to the Architects and Owners attention. Install system per reviewed shop drawings.

F. Administrative
1. Permit application
2. Pay all plan review and inspection fees
3. Include the following installing contractor’s information:
   a. Installing contractors name, address phone number.
   b. Contractor’s license number.
   c. Local business license number.
   d. Include a copy of workers compensation insurance certificate.
   e. Evidence of Contractor personnel NICET Certification.
   f. List of contractor’s personnel who will be working on the installation.
4. Include the following Project information:
   a. Site address.
   b. Basis for installation / Building code occupancy classification.

G. Fire alarm equipment
1. Include manufacturers specification sheets for all components
2. Identify equipment application per listing and approvals
3. Include CSFM listing sheets for all required systems and components numbers

H. General information
1. Indicate appropriate codes and standards, including reference edition.
2. Indicate type of system or service involved.
3. Include written sequence of operation or matrix table.
4. Indicate HVAC equipment locations and CFM.
5. Indicate any special system features or operations.
6. Indicate all required identification and labeling. Include locations for each item and proposed nomenclature.

I. Plans and details
Include the following information:

a. Scaled reflected ceiling and floor plans, including north reference.

b. Completed title block indicating project site address and installing contractors address.

c. Identify each room and its proposed use.

d. Locate all devices, cabinets and components including end of line devices.

e. Accurate legend of symbols for all fire alarm devices being installed, conforming with construction documents.

f. Identify circuit styles, designations and methods.

g. Include building cross sections, include attic, soffit or ceiling details.

h. Indicate location of sprinkler system test valve.

i. Include voltage drop calculations.

j. Include description of zone assignments / device addresses.

k. Indicate through penetration fire stopping details and specifications.

l. Include reflected ceiling plans showing duct diffusers, lighting fixtures, sprinklers, ceiling types and changes in elevations. Locate all fire alarm ceiling mounted devices in relation to work of other trades and other ceiling components.

m. Elevation detail of manual pull station installation and visual alarm signaling devices. Note that existing device mounting heights and locations may not comply with current codes.

n. Indicate device mounting heights coordinated with architectural elevations for wall mounted initiation and notification devices.

o. Include power supply source and details.

J. Riser diagram

1. Indicate conductor information:

a. Size.

b. Stranding.

c. Insulation type.

2. Identification of wire quantities and conduit or raceway sizes.

3. Include conduit fill calculations.

4. Indicate locations for end of line devices

K. Additional requirements

1. Point-to-point wiring diagrams for overall system and components, including 120-volt power distribution and interface with the HVAC and fire protection systems.

2. Typical device wiring diagrams.

3. Battery calculations to meet AHJ minimum hour requirements.

4. Details for support and anchorage of all fire alarm equipment weighing over 20 pounds.

5. Include physical and electrical characteristics of equipment to indicate conformance with the specifications.

6. Annunciator configuration and designations.

7. Revised panel schedules showing 120-volt circuit loads.

8. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.

9. Device Address List: Coordinate with final system programming.
10. Duct Smoke Detectors: Performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

11. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer’s written recommendations.

12. Audible/visual/Alarm Signaling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.06 SAMPLE WARRANTY: FOR SPECIAL WARRANTY.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01 78 23 “Operation and Maintenance Data,” include the following and deliver copies to authorities having jurisdiction:
      a. Comply with the “Records” section of the “Inspection, Testing and Maintenance” chapter in NFPA 72.
      b. Provide “Fire Alarm and Emergency Communications System Record of Completion Documents” according to the “Completion Documents” Article in the “Documentation” section of the “Fundamentals” chapter in NFPA 72.
      c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
      d. Riser diagram.
      e. Device addresses.
      f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
      g. Record copy of site-specific software.
      h. Provide “Inspection and Testing Form” according to the “Inspection, Testing and Maintenance” chapter in NFPA 72, and include the following:
1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.
   i. Manufacturer's required maintenance related to system warranty requirements.
   j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
   2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
   3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
   4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
   5. Keys and Tools: One extra set for access to locked or tamper-proofed components.
   6. Audible and Visual Notification Appliances: One of each type installed.
   7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
   8. Filters for Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
   9. Air-Sampling Fan: Quantity equal to one for every five detectors, but no fewer than one unit of each type.

1.09 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level IV technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).
D. NFPA Certification: Obtain certification according to NFPA 72 by a UL listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 by

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it “NOT IN SERVICE” until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment “NOT IN SERVICE” until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
   1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
   2. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Automatic sensitivity control of certain smoke detectors.

B. All components provided shall be listed for use with the selected system.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices. Retain only those devices and systems in subparagraphs below applicable to Project. Coordinate with requirements in other Sections that specify listed devices and systems.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Fire-extinguishing system operation.
8. Fire standpipe system.
9. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control panel, connected network control panels, off-premises network control panels, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighters’ smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Recall elevators to primary or alternate recall floors.
12. Activate elevator power shunt trip.
13. Activate emergency lighting control.

C. or more of the following devices and actions:
1. Valve supervisory switch.
2. Alert and Action signals of air-sampling detector system.
3. Elevator shunt-trip supervision.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.
6. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
E. System Supervisory Signal Actions:
   1. Initiate notification appliances.
   2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
   3. Record the event on system printer.
   4. After a time-delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
   5. Display system status on graphic annunciator.

2.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.”

2.04 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, system shall be the following:
   1. Siemens XLSV

B. General Requirements for Fire-Alarm Control Unit:
   1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
      a. System software and programs shall be held in non-volatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
      b. Include a real-time clock for time annotation of events on the event recorder and printer.
      c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
      d. The FACP shall be listed for connection to a central-station signaling system service.
      e. Provide non-volatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
   2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
   3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   1. Annunciator and Display: Liquid-crystal type, two line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
   1. Pathway Class Designations: NFPA 72, Class B.
   2. Pathway Survivability: Level 0.
   3. Install no more than 50 addressable devices on each signaling-line circuit.
   4. Serial Interfaces:
      a. One dedicated RS 485 port for remote station operation using point ID DACT.
      b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
      c. One USB port for PC configuration.
      d. One RS 232 port for voice evacuation interface.

E. Smoke-Alarm Verification:
   1. Initiate audible and visible indication of an “alarm-verification” signal at fire-alarm control unit.
   2. Activate an approved “alarm-verification” sequence at fire-alarm control unit and detector.
   3. Record events by the system printer.
   4. Sound general alarm if the alarm is verified.
   5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:
   1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
   2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
   3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Elevator Recall:
   1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
      a. Elevator lobby detectors except the lobby detector on the designated floor.
      b. Smoke detector in elevator machine room.
      c. Smoke detectors in elevator hoistway.
   2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
   3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
      a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out the final adjusted values on system printer.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center.
   1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
      a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
      b. Programmable tone and message sequence selection.
      c. Standard digitally recorded messages for “Evacuation” and “All Clear.”
      d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control panel.
   2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters’ two-way telephone communication zones.
   3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

L. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

M. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters and alarm radio transmitters shall be powered by 24-V dc source.
   1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
O. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.05 MANUAL FIRE-ALARM BOXES

A. Manufacturers:
   1. Siemens

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
   1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.
   3. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.06 SYSTEM SMOKE DETECTORS

A. Manufacturers:
   1. Siemens

B. General Requirements for System Smoke Detectors:
   1. Comply with UL 268; operating at 24-V dc, nominal.
   2. Detectors shall be four-wire type.
   3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
   4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
   6. Integral Visual-Indicating Light: LED type, indicating detector has operated power-on status.
   7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

C. Photoelectric Smoke Detectors:
   1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
   2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      a. Primary status.
      b. Device type.
      c. Present average value.
d. Present sensitivity selected.
e. Sensor range (normal, dirty, etc.).

D. Ionization Smoke Detector:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector’s location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector’s location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.07 HEAT DETECTORS

A. Manufacturers:
1. Siemens

B. General Requirements for Heat Detectors: Comply with UL 521.
1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
1. Mounting: Adapter plate for outlet box mounting Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F
1. Mounting: Adapter plate for outlet box mounting] [Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.08 NOTIFICATION APPLIANCES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Siemens
   2. System Sensor.
   3. Wheelock; a brand of Eaton.

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

C. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

D. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

E. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

F. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

G. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word “FIRE” is engraved in minimum 1 inch (25mm) high letters on the lens.
   1. Rated Light Output:
      a. 153075110 [177] cd.
      b. 15/30/75/110 cd, selectable in the field.
   2. Mounting: Wall mounted unless otherwise indicated.
   3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   4. Flashing shall be in a temporal pattern, synchronized with other units.
   5. Strobe Leads: Factory connected to screw terminals.
   6. Mounting Faceplate: Factory finished, red

H. Voice/Tone Notification Appliances:
   1. Comply with UL 1480.
   2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the “Notification Appliances” and “Emergency Communications Systems” chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: Flush
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

I. Exit Marking Audible Notification Appliance:
1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.09 FIREFIGHTERS’ TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control panel, the fire command center and remote firefighters’ telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
1. Common-talk type for firefighter use only.
2. Selective-talk type for use by firefighters and fire wardens.
3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. An indicator lamp shall flash if a phone is disconnected from the talk circuits.
4. Addressable firefighters’ phone modules to monitor and control a loop of firefighter phones. Module shall be capable of differentiating between normal, off-hook, and trouble conditions.
5. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is taken off the hook, it causes an audible signal to sound and a high-intensity lamp to flash at the fire-alarm control panel fire command center.
6. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
7. Display: Graphic to indicate location of caller.
8. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
   a. Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating “Fire Warden Phone” or “Fire Emergency Phone.”
   b. With “break-glass” type door access lock.
10. Handsets: push-to-talk-type sets with noise-canceling microphone stored in a cabinet adjacent to fire-alarm control panel in the fire command center.

2.10 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.11 ADDRESSABLE INTERFACE DEVICE

A. General:
   1. Include address-setting means on the module.
   2. Store an internal identifying code for control panel use to identify the module type.
   3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall to circuit-breaker shunt trip for power shutdown.
   1. Allow the control panel to switch the relay contacts on command.
   2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a pre-set number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. Primary line shall be cellular communication, and secondary line is telephone (POTS) line. If service is lost on cellular signal or telephone line, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:
   1. Verification that both telephone lines are available.
   2. Programming device.
   3. LED display.
   5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:
   1. Address of the alarm-initiating device.
   2. Address of the supervisory signal.
   3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.13 RADIO ALARM TRANSMITTER

A. Transmitter shall comply with NFPA 1221 and 47 CFR 90.

B. Description: Manufacturer’s standard commercial product; factory assembled, wired, and tested; ready for installation and operation.
   1. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
   2. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
   5. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph with a gust factor of 1.3 without failure.
   6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
   8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.

C. Functional Performance: Unit shall receive alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:
   1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
   2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
4. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
5. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.

2.14 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.
B. Provide network communications pathway per manufacturer’s written requirements and requirements in NFPA 72 and NFPA 70.
C. Provide integration gateway using BACnet Modbus for connection to building automation system.

2.15 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.16 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   1. Factory fabricated and furnished by device manufacturer.
   2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
   1. Verify that manufacturer’s written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply
with requirements in NFPA 70 including, but not limited to, Article 760, “Fire Alarm Systems.”

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer’s written storage instructions.

B. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in Section 03 30 00 “Cast-in-Place Concrete.” Section 03 30 53 “Miscellaneous Cast-in-Place Concrete.”

1. Install seismic bracing. Comply with requirements in Section 27 05 48.16 “Seismic Controls for Communications Systems.”
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (460-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 27 05 48.16 “Seismic Controls for Communications Systems.”

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 27 05 48.16 “Seismic Controls for Communications Systems.”

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.
4. Pull Station can be either single or dual action.

F. Smoke- or Heat-Detector Spacing:

1. Comply with the “Smoke-Sensing Fire Detectors” section in the “Initiating Devices” chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the “Heat-Sensing Fire Detectors” section in the “Initiating Devices” chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet (9 m)
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches (910 mm), 60 inches (1520 mm) from air-supply diffuser or return-air opening.

6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

G. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.
   1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

I. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.

J. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

K. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

L. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

M. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

N. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

O. Device Location-Indicating Lights: Locate in public space near the device they monitor.

P. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph (160-km/h) load with a gust factor of 1.3 without damage.

3.03 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.
1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

D. Riser cabling shall be in 2 hour rated enclosure and must be FPLR cable type.

E. Where allowable by AHJ, per CBC riser cabling not installed in 2 hour rated enclosure shall be “Class A” (redundant) style wiring.

3.04 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 08 71 00 “Door Hardware.” Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters’ smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Magnetically held-open doors.
5. Electronically locked doors and access gates.
6. Alarm-initiating connection to elevator recall system and components.
7. Alarm-initiating connection to activate emergency lighting control.
8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
11. Supervisory connections at elevator shunt-trip breaker.
12. Data communication circuits for connection to building management system.
13. Data communication circuits for connection to mass notification system.
15. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
16. Supervisory connections at fire-pump engine control panel.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 27 05 53 “Identification for Communications Systems.”
Install framed instructions in a location visible from fire-alarm control unit.

3.06 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.07 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction

B. Manufacturer’s Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Visual Inspection: Conduct visual inspection prior to testing.
      a. Inspection shall be based on completed record Drawings and system documentation that is required by the “Completion Documents, Preparation” table in the “Documentation” section of the “Fundamentals” chapter in NFPA 72.
      b. Comply with the “Visual Inspection Frequencies” table in the “Inspection” section of the “Inspection, Testing and Maintenance” chapter in NFPA 72; retain the “Initial/Reacceptance” column and list only the installed components.
   3. Test audible appliances for the public operating mode according to manufacturer’s written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   4. Test audible appliances for the private operating mode according to manufacturer’s written instructions.
   5. Test visible appliances for the public operating mode according to manufacturer’s written instructions.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.
H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semi-annual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.08 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include full maintenance by skilled employees of manufacturer’s designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer’s authorized replacement parts and supplies.
   1. Include visual inspections according to the “Visual Inspection Frequencies” table in the “Testing” paragraph of the “Inspection, Testing and Maintenance” chapter in NFPA 72.

3.09 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION
SECTION 31 11 00
CLEARING & GRUBBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes all work necessary to successfully complete demolition, clearing & grubbing to prepare site for the phasing and new construction, including the following:
   1. Protecting existing trees and vegetation to remain.
   2. Trimming tree limbs and roots.
   3. Removing trees as designated.
   4. Clearing vegetation, debris, trash and other materials within limits indicated.
   5. Grubbing of vegetation within limits indicated.
   7. Removing above-grade site improvements within limits indicated.
   8. Disconnecting, capping or sealing, and abandoning site utilities in place.
   9. Disconnecting, capping or sealing, and removing site utilities.
  10. Disposing of objectionable material off site.
  11. Clean line saw cutting of existing asphalt pavement, concrete sidewalks, concrete curb/gutter, etc., as specified herein.
  13. Protection from injury or defacement of trees and other vegetation and objects to be preserved.
      a. Removal of surface debris and deleterious materials such as rubbish.
      b. Removal and stockpile of materials for landscaping use at approved location.
      c. Disposal of unwanted materials off site.

1.2 RELATED DOCUMENTS

A. Geotechnical Report: “Geotechnical Investigation for Proposed Physical Education Complex (D-4012), Diablo Valley College, 321 Golf Club Road, Pleasant Hill, CA.” RMA Project No.: 16-772-0, Dated: September 19, 2018

B. Caltrans Standard Specifications, Section 16, Clearing and Grubbing.
1.3 REGULATORY REQUIREMENTS

A. No burning shall be allowed.

B. Comply with the following California Code of Regulations:
   1. Title 8: CAL/OSHA, Chapter, Subchapter 4 – Construction Safety Orders
   2. Title 24: Part 2, California Building Code, Chapter 33, Protection of Pedestrian during Construction or Demolition.
   3. Bay Area Air Quality Management District
   4. Alameda County Water District, Standard Specification and Details.
   5. County of Alameda County Public Works Department, Design Guidelines.

1.4 DEFINITIONS


B. CAL-OSHA: California Occupational Safety and Health Administration.

C. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2-inches in diameter; and free of weeds, roots, and other deleterious materials.

D. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.5 MATERIAL DISTRICTSHIP

A. Except for stripped topsoil or other materials indicated to remain District’s property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements.

1.7 QUALITY ASSURANCE

A. Do not remove or prune trees without first securing a permit from the appropriate agency.

B. Prune to the standards of the International Society of Arborists and to ANSI 300.
1.8 PROJECT CONDITIONS

A. Except for materials indicated to be stockpiled or to remain the District’s property, cleared materials are the Contractor’s property. Remove cleared materials from site and dispose of in lawful manner.

B. Salvageable Improvements: Carefully remove items indicated to be salvaged and store where indicated on plans or where designated by the District. Avoid damaging materials designated for salvage.

C. Unidentified Materials;
   1. If unidentified materials are discovered, including hazardous materials that will require additional removal other than is required by the Contract Documents, immediately report the discovery to the District.
   2. If necessary, the District will arrange for any testing or analysis of the discovered materials and will provide instructions regarding the removal and disposal of the unidentified materials.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Backfill excavations resulting from demolition operations with on-site or import materials conforming to structural backfill defined in Section 31 23 33 Utility Trenching and Backfill.
   1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain during construction.
   1. Restore damaged improvements to their original condition, as acceptable to the Engineer and/or District. Prior to restoration the contractor shall notify Engineer and/or District of the damaged improvements.
3.2 TREE PROTECTION

A. Erect and maintain temporary fence around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove fence when construction is complete.

B. Do not store construction materials, debris, or excavated material within drip line of remaining trees.

C. Do not permit vehicles or equipment within drip line of remaining trees.

D. Do not excavate within drip line of remaining trees, unless otherwise indicated.

E. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation edge as possible.
   1. Cover exposed roots with burlap and water regularly.
   2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
   3. Coat cut faces of roots more than 1-1/2-inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
   4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

3.3 TREE PRUNING

A. Prune trees to balance the crown, and eliminate hazards. Perform main work to reduce sail effect through thinning, reducing end weights, shortening long heavy limbs, removing deadwood, weak limbs and sucker growth. Prune limbs back to an appropriate lateral branch.

B. Make final cuts at the outer edge of the branch collar in accordance with the arborist's recommendations.

C. Perform pruning work in a safe and proper manner, adhering to CAL-OSHA and ANSI Standards.

3.4 ROOT PRUNING

A. Do not cut tree roots greater than 3-inch in diameter and less than 12-inches below ground level without approval of the District.

B. Cut tree roots cleanly, as far from the trunk as possible, and not underneath any area where walkways are to be constructed. Root pruning shall be to a depth of 18-
C. Tree root prune using a Vermeer root-cutting machine. Obtain the District's approval before using alternate equipment or techniques.

D. Complete tree root pruning prior to any excavation adjacent to the tree.

E. Do not expose tree roots to drying out. Cover root ends with soil or burlap and keep moist until the final backfill is completed.

3.5 TREE REMOVAL

A. Remove trees designated for removal prior to the construction of new improvements.

B. Perform tree removal work in a safe and proper manner, adhering to CAL-OSHA and ANSI Standards.

C. Remove or grind stumps to a minimum of 18-inches below finish subgrade. Remove surface roots to this depth within 24-inches of the tree trunk. Trees, plants and roots that are below proposed building footprint or slabs on grade shall be removed in its entirety.

3.6 RESTORATION

A. Restore damaged improvements to their original condition, as acceptable to the District.

B. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, as directed by the District.
   1. Employ a qualified arborist, licensed in jurisdiction where the Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
   2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the District. Clear and grub existing areas only to extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations.

3.7 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed or abandoned.

B. Arrange to shut off indicated utilities with utility companies or verify that utilities have been shut off.
C. Existing Utilities: Do not interrupt utilities serving facilities occupied by District or others unless authorized in writing by the District, and then only after arranging to provide temporary utility services according to requirements indicated.

D. Coordinate utility interruptions with utility company affected.

E. Do not proceed with utility interruptions without the permission of the District and utility company affected. Notify District and utility company affected 14 working days prior to utility interruptions.

F. Excavate and remove underground utilities that are indicated to be removed.

G. Securely close ends of abandoned piping with tight fitting plug or wall of concrete minimum 6-inches thick. All abandoned piping shall be filled with a cementious material, such as controlled low strength material.

3.8 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.

B. Remove trash, debris, logs, concrete, masonry and other waste materials.

C. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.

D. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18-inches below subgrade. Trees, plants and roots that are below proposed building footprint or slabs on grade shall be removed in its entirety.

E. Use only hand methods for grubbing within drip line of remaining trees.

3.9 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Remove trash, debris, weeds, roots, and other waste materials.

D. Stockpile topsoil materials designated to remain on site at a location approved by the District at a location away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust. Refer to the SWPPP as required.

E. Do not stockpile topsoil within drip line of remaining trees.
3.10 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, and gutters, as indicated. Where concrete slabs, curb, gutter and asphalt pavements are designated to be removed, remove bases and subbase to surface of underlying, undisturbed soil.

C. Unless the existing full-depth joints coincide with line of pavement demolition, neatly saw-cut to full depth the length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

D. Remove driveways, curbs, gutters and sidewalks by saw cutting to full depth. If saw cut falls within 30-inches of a construction joint, expansions joint, score mark or edge, remove material to joint, mark or edge.

3.11 BACKFILL

A. Place and compact material in excavations and depressions remaining after site clearing in conformance with Section 31 23 33.

3.12 DISPOSAL

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off the District’s property.

3.13 TEMPORARY FACILITIES

A. Provide the following temporary facilities to facilitate the demolition operations, as necessary.
   1. Temp Traffic Controls
   2. Protection of Persons and Property
   3. Protection of Utilities
   4. Noise and Dust Abatement.
   5. Clear and restore area to their original condition.
   6. Protect survey markers and monuments, existing improvements, and adjacent structures from removal and damage.
3.14 CONSTRUCTION WASTE MANAGEMENT

A. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the General Contractor’s Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION

A. Work Included: Provide protection of all existing plants and planted areas indicated to remain as shown on Drawings.

B. Related Work:
   1. Sustainable Design Requirements (LEED) - Section 01 81 13
   2. Finish Grading - Section 31 22 19
   3. Planting - Section 32 93 00
   4. Landscape Maintenance - Section 32 93 25

1.02 PROJECT CONDITIONS

A. Review: Visit and walk the site with the District's Representative to clarify scope of work and understand project conditions prior to the start of demolition.

B. Documentation: Confirm location of all plant materials designated on Drawings as "Existing to Remain". Examine existing irrigation system to remain or to connect with and report all malfunctioning equipment, to be repaired by District. Record all discrepancies and all conditions which threaten existing plantings.

C. Acceptance: Commencing work shall be taken as acceptance by the Contractor of responsibility for the protection of all existing site plantings, with the exception of discrepancies and corrections noted above.

1.03 SUBMITTALS

A. Shop Drawings: Construction details for protective barriers and barricades as required.

B. Schedule: Watering schedule, where interruption of irrigation systems will exceed one watering period.

1.04 DEFINITIONS

A. Protection: Provide all barricades as required to prevent all damage to existing plant materials to remain, including but not limited to protection from mechanical damage, and soil compaction, pollution from all sources, and disruption of environmental support which would result in the loss of vigor of said plantings.

B. Drip Line: An imaginary line on the ground around a tree representing its outermost branch tips. All of the area within the drip line of existing trees to remain is to be protected from damage as specified herein, unless otherwise noted.
1.05 SCHEDULING

A. As required, construct protective barriers prior to demolition and selective clearing. Construct other barriers as scope of work progresses.

1.06 QUALITY ASSURANCE

A. Standards of workmanship shall conform to those recommended by:

1.07 WARRANTY

A. General: During the Warranty Period for new plantings, similarity warrant all existing plant materials against decline resulting from damage during construction. See Section 32 93 00 - Planting.

B. Exclusions: Damage due to vandalism, Acts of Nature, or neglect by District.

1.08 REPLACEMENTS

A. General: Existing planting to remain which exhibits conditions which are determined as unacceptable due to inadequate protection during construction shall be replaced by Contractor at no expense to District.

B. Quality: Closely match replacements to adjacent specimens of the same species and size.

C. Planting, Maintenance, and Warranty of Replanted Materials: See Section 32 93 00 - Planting.

1.09 FINAL ACCEPTANCE: See Section 32 93 25 - Landscape Maintenance.

PART 2 - PRODUCTS

2.01 MANUFACTURERS: Fertilizers, Herbicides, and Pest Control - See Section 32 93 00 - Planting, and Section 32 93 25 - Landscape Maintenance.

2.02 SAFETY: Provide all reflective signage and/or flashers as required by all codes and ordinances affecting barricaded plantings to remain.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide barriers at the drip line of all trees designated to remain. Similarly protect planting areas from construction activities.
3.02 OPERATIONS

A. Storage: Do not store materials or equipment under the branches of existing trees nor in planting areas to remain.

B. Traffic: Do not operate nor park equipment within the drip line of existing trees to remain. Keep foot traffic out of existing planting areas. Protect planting areas from cross traffic.

3.03 EXCAVATING AND GRADING

A. Cut: Do not permit machine excavation within the drip line of existing trees to remain. All such work shall be hand labor. Do not permit more than two (2) inches of existing soil to be removed within the drip line except as authorized in writing by District.

B. Fill: Do not permit stockpiling of soil within the drip line of existing trees nor on existing planting areas. Do not permit more than three (3) inches of fill to be placed within the drip line during grading operations without written acceptance of Landscape Architect.

3.04 MAINTENANCE OF EXISTING PLANTING

A. General: During the Maintenance Period for new planting, similarly maintain all existing plantings to remain. See Section 32 93 25 - Landscape Maintenance.

B. Fertilizers: Do not use complete fertilizers on existing plant materials unless soils test indicates specific nutrient deficiencies.

C. Non-irrigated existing areas: Prior to and throughout construction install and maintain temporary irrigation to all existing plantings to remain including those indicated on the drawings.

D. Existing Irrigated Areas to Remain: Keep irrigation operable throughout construction.

E. Mulch: Maintain 6-inch thickness of mulch at trees to remain and 3-inch thickness of mulch at shrubs to remain throughout the duration of construction.

3.05 CLEAN UP

A. At close of construction, remove all protective barriers at the direction of the District’s Representative. Transport all barrier materials off site at no additional expense to District.

B. Repair all grades and restore all damaged plant materials.

END OF SECTION
SECTION 31 23 00
EXCAVATION AND FILL

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes the requirements for earthwork operation, as shown on the Drawings and specified:
   1. Excavation and/or embankment from existing ground to subgrade, including soil sterilant, for parking areas, walks, paths, and any other site improvements called for on the Plans.
      a. Aggregate base.
      b. Dispose off-site waste, excess or unsatisfactory material.

1.02 RELATED DOCUMENTS

A. Geotechnical Report: “Geotechnical Investigation for Proposed Art Center Complex (D-4014), Diablo Valley College, 321 Golf Club Road, Pleasant Hill, CA.” RMA Project No.: 16-0772-0, Dated: June 29, 2018

B. Geotechnical Report: “Geotechnical Investigation for Proposed Physical Education Complex (D-4012)” Diablo Valley College, 321 Golf Club Road, Pleasant Hill, CA, prepared by RMA Group, November 16, 2017

1.03 REGULATORY REQUIREMENTS

A. State of California, Department of Transportation (Caltrans), Standard Specifications

B. ASTM
   1. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
   2. D1557-70 for testing in compaction.
   3. D 1586, Method for Penetration Tests and Split-Barrel Sampling of Soils.
   4. D 2487, Classification of Soils for Engineering Purposes.


D. CAL/OSHA, Title 8.
1.04 DEFINITIONS

A. Borrow: Approved soil material imported from off-site for use as Structural Fill or Backfill.

B. Excavation: Removal of material encountered above subgrade elevations.
   1. Authorized Over-Excavation: Excavation below subgrade elevations or beyond indicated horizontal dimensions as shown on plans or authorized by the District’s Representative.
   2. Unauthorized Over-Excavation: Excavation below subgrade elevations or beyond indicated horizontal dimensions without authorization by the District’s Representative. Unauthorized excavation shall be without additional compensation.

C. Structural Backfill: Soil materials approved by the District’s Representative and used to fill excavations resulting from removal of existing below grade facilities, including trees.

D. Structural Fill: Soil materials approved by the District’s Representative and used to raise existing grades.

E. Rock: Rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material ¾-cubic yards or more in volume that when tested by an independent geotechnical testing agency, according to ASTM D 1586, exceeds a standard penetration resistance of 100 blows/2-inches.

F. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man made stationary features constructed above or below grade.

G. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below base or topsoil materials.

H. Unsuitable Material: Any soil material that is not suitable for a specific use on the Project. The District’s Representative will determine if a soil material is unsuitable.

I. Utilities: onsite underground pipes, conduits, ducts and cables.

1.05 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements.

B. Submit material certificates signed by the material producer and the Contractor, certifying that that each material item complies with, or exceeds the specified requirements.

1.06 QUALITY ASSURANCE

A. Conform all work and materials to the recommendations or requirements of the District’s Representative.
B. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM D 1557.

C. Excavate and backfill existing areas only to extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations. Backfill as necessary to achieve rough grade elevations as indicated per plan.

D. Perform excavation, filling, compaction and related earthwork under the observation of the District’s Representative. Materials placed without approval of the District’s Representative will be presumed to be defective and, at the discretion of the District’s Representative, shall be removed and replaced at no cost to the District. Notify the District’s Representative at least 24-hours prior to commencement of earthwork and at least 48 hours prior to testing.

E. The District’s Representative will perform observations and tests required to enable him to form an opinion of the acceptability of the Project earthwork. Correct earthwork that, in the opinion of the District’s Representative, does not meet the requirements of these Technical Specifications.

F. Upon completion of the construction work, certify that all compacted fills and foundations are in place at the correct locations, and have been constructed in accordance with sound construction practice. In addition, certify that the materials used are of the types, quality and quantity required by these Technical Specifications. The Contractor shall be responsible for the stability of all fills and backfills constructed by his forces and shall replace portions that in the opinion of the District’s Representative have been displaced or are otherwise unsatisfactory due to the Contractor’s operations.

G. Do not mix or place cement treated base when the temperature is below 36 degrees F or when the ground is frozen.

H. Identify and protect existing utilities.

I. Finish soil grade tolerance at completion of grading:
   1. Paved areas: +0.05
   2. Other areas: ±0.10 feet.

1.07 PROJECT CONDITIONS

A. Promptly notify the District and the District’s Representative of surface or subsurface conditions differing from those disclosed in conformance with Division 1 General Requirements.

B. Protect open excavations, trenches, and the like with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.

C. Prevent erosion of freshly graded areas during construction and until such time as permanent drainage and erosion control measures have been installed.
D. Temporarily stockpile fill material in an orderly and safe manner and in a location approved by the District.

E. Provide dust and noise control in conformance with Division 1 General Requirements.

F. Environmental Requirements: When unfavorable weather conditions necessitate interrupting earthwork operation, areas shall be prepared by compaction of surface and grading to avoid collection of water. Provide adequate temporary drainage to prevent erosion. After interruption, compaction specified in last layer shall be re-established before resuming work.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.

B. Obtain approval of on-site soil materials and borrow materials to be used for structural fill or structural backfill from the District’s Representative.

C. On-Site Structural Fill and Structural Backfill: Soil or soil-rock mixture from on site excavations, free from organic matter or other deleterious substances. On-site structural fill and backfill shall not contain rocks or rock fragments over 3 inches in greatest dimension.

D. Imported Structural Fill and Structural Backfill: Conform to the requirements of on-site structural fill. Material shall also be a non-expansive and predominantly granular soil or soil-rock mixture with plasticity index of 8 or less, has a liquid limit less than 25, and an R-Value of 25 or greater.

2.02 SOIL STERILANT

A. Commercial chemical for weed control, registered by EPA. Provide granular, liquid or wet-able powder form.

2.03 AGGREGATE BASE

   1. Class 2, 1-1/2-inch Maximum: Section 26-1.02A.
   2. Class 2, 3/4-inch Maximum: Section 26-1.02A.
   3. Class 3: Section 26-1.02B.

PART 3 - EXECUTION

3.01 GENERAL

A. Conform to Section 19, Earthwork, Caltrans Standard Specifications as modified by the Contract Documents.
B. Placement and compaction of material by flooding, ponding, or jetting will not be permitted.

C. The use of explosives will not be permitted.

3.02 WET WEATHER CONDITIONS

A. Do not prepare subgrade, place or compact soil materials if above optimum moisture content.

B. If the District’s Representative allows work to continue during wet weather conditions, conform to supplemental recommendations provided by the District’s Representative.

3.03 EXCAVATION

A. Excavate earth and rock to lines and grades shown on drawings as prepared by a licensed professional engineer and to the neat dimensions indicated on the Plans, required herein or as required to satisfactorily compact backfill.

B. Remove and dispose of large rocks, pieces of concrete and other obstructions encountered during excavation.

C. Where forming is required, excavate only as much material as necessary to permit placing and removing forms.

D. Provide supports, shoring and sheet piles required to support the sides of excavations or for protection of adjacent existing improvements.

3.04 REMOVAL OF EXISTING FILLS, UNSUITABLE MATERIAL, AND OVEREXCAVATION

A. Conform with Division 1 General Requirements.

B. Over-excavate areas of existing fills and other unsuitable material encountered during mass grading as directed by the District's Representative.
   1. All vegetation, trash and debris should be cleared from the grading area and removed from the site. Prior to placement of compacted fills, all non-engineered fills and loose, porous, or compressible soils will need to be removed down to competent ground. Removal and requirements will also apply to cut areas, if the depth of cut is not sufficient to reach competent ground. Removed and/or overexcavated soils may be moisture-conditioned and re-compacted as engineered fill, except for soils containing detrimental amounts of organic material. Estimated depths of removals are as follows:
      a. Non-engineered fill 4 feet depth and 5 feet outside of the prosed building footprint will need to be removed. Complete removal of these fills will need to be performed. If other non-engineered fills are encountered during grading, they will also need to be removed along with any underlying compressible native soils. Soils disturbed by demolition of existing structures will need to be over-excavated to competent native ground and then scarified to a minimum depth of 12 inches, moisture conditioned and compacted to at least 90 percent of the maximum dry density.
C. The asphalt and concrete currently onsite may be either processed and placed in the compacted fill, or hauled off the site. If the asphalt and concrete is use as fill material, it must be broken down to approximately 4 to 8 inch particles and mixed thoroughly with on-site soils. No large and flat pieces are to be used for fill. If asphalt is processed by grinding, it cannot be used in fills and must be removed from the site.

D. If grading will remove soils from within the foundation zone of influence of the existing structures, the overexcavation should be performed using a series of slot cuts. No more than 20 feet of soil adjacent to an existing foundation should be removed at one time within a given 60 foot length. All excavations made adjacent to existing foundations that will encroach into the foundation zone of influence should be backfilled during the same shift. The figure below illustrates a typical slot cut procedure:

![Diagram of slot cut procedure]

E. In addition to the above requirements, overexcavation will also need to meet the following criteria for the building pads, concrete flatwork and pavement areas:

- In order to provide a uniform bearing surface for the slabs on grade and verify that shallow bedrock is not present within the building footprint, a minimum over-excavation of the entire building footprint is recommended. Following removal of the undocumented fills discussed above, the building area should be over-excavated to provide for an engineered fill mat having a minimum thickness of 4 feet measured from the surface on which the proposed floor slabs will rest and compacted to 90% relative compaction. The building area should include the foundation footprint plus the area extending horizontally from the edge of the foundation perimeter for a distance of 5 feet.

F. In order to mitigate the effects of expansive soils, the fill mat discussed above should be composed of non-expansive soil discussed in greater detail in Section 3.05.

G. In footing areas, both continuous and spread, shall be undercut, moistened, and compacted as necessary to produce soils compacted to a minimum of 90% relative compaction to a depth equal to the width of the footing below the bottom of the footing or to a depth of 3 feet below the bottom of the footing, whichever is less. Footing areas shall be defined as the area extending from the edge of the footing for a distance of 5 feet.

H. All floor concrete flatwork and paved areas shall be underlain by a minimum of 12 inches of soil compacted to a minimum of 90% relative compaction.
I. The exposed soils beneath all overexcavation should be scarified an additional 12 inches, moisture conditioned and compacted to a minimum of 90% relative compaction.

3.05 NON-EXPANSIVE ENGINEERED FILL MATERIALS

A. Non-expansive engineered fill materials may be composed of soils having an expansion index of 20 or less and a plasticity index of 15 or less when tested in accordance with ASTM D4829 and D4318, respectively. Non-expansive soils may consist of materials imported from offsite source, soils excavated from onsite source found to be non-expansive, or may consist of over-excavated soils treated with Lime. If the lime-treatment alternative is utilized, a dosage of 4 percent by dry weight of untreated soil may be utilized for estimation purposes only. The final lime treatment dosage should be determined by the lime treatment contractor based on laboratory testing. An in-place density of 100 pounds per cubic foot may be utilized for estimating lime spread rates. The final spread rate should be based on in-place density testing of the untreated soils performed prior to lime spreading.

3.06 GRADING

A. Uniformly grade the Project to meet existing conditions.

B. Finish ditches, gutters and swales to the sections, lines and grades indicated and to permit proper surface drainage.

C. Round tops and bottoms of slopes as indicated or to blend with existing contours.

3.07 SUBGRADE PREPARATION

A. Prepare subgrades under paved areas, curbs, gutters, walks, structures, other surface facilities and areas to receive structural fill. At least 12 inches of select material shall be placed beneath exterior flatwork and extend at least two feet beyond the slab edges.

B. Prepare subgrades for paved areas, curbs and gutters by plowing or scarifying surface at least 12 inches in one lift below final subgrade elevations and 1-foot beyond edge of pavement unless specified otherwise by the District’s Representative. Uniformly moisture condition to obtain optimum moisture contents. Break clods and condition surface by harrowing or dry rolling. Remove boulders, hard ribs and solid rock. Prepare earth uniform for full depth and width of subgrade.

C. Protect utilities from damage during compaction of subgrades and until placement of final pavements or other surface facilities.

D. Obtain the District’s Representative’s approval of subgrades prior to placing pavement.

3.08 PLACEMENT OF STRUCTURAL FILL

A. Obtain the District’s Representative’s approval of surface to receive structural fill prior to placement of structural fill material.

B. Place structural fill on prepared subgrade.
C. Spread structural fill material in uniform lifts not more than 8-inches in un-compacted thickness and compact.

D. Place structural fill material to suitable elevations above grade to provide for anticipated settlement and shrinkage.

E. Overbuild fill slopes, as required by the District’s Representative, to obtain required compaction. Remove excess material to lines and grades indicated.

F. Do not drop fill on structures. Do not backfill around, against or upon concrete or masonry structures until structure has attained sufficient strength to withstand loads imposed and the horizontal structural system had been installed.

3.09 AGGREGATE BASE

A. Watering, Spreading and Compacting: Section 26-1.035, 26-1.04 and 26-1.05 of Caltrans Standard Specifications.

3.10 COMPACATION AND TESTING

A. Do not compact by ponding, flooding or jetting.

B. Compact soils at optimum water content. Aerate material if it is too wet. Add water to material if it is too dry. Thoroughly mix lifts before compaction to ensure uniform moisture distribution.

C. Perform compaction using rollers, pneumatic or vibratory compactors or other equipment and mechanical methods approved by the District’s Representative.

D. Compaction requirements:
   1. Compact structural fills less than 5-feet thick to 90 percent compaction.
   2. Compact structural fill 5-feet thick or greater to 95 percent compaction.
   3. Compact the upper 6 inches of subgrade soils beneath pavements, curbs and gutters to 95 percent compaction. Extend compaction 2-feet beyond pavement edges unless specified otherwise by the District's Representative.
   4. Compact the upper 6-inches of subgrade soils under walks, structures and areas to receive structural fill to 90 percent compaction.

3.11 SOIL STERILIZATION

A. Apply soil sterilant to areas indicated, such as beneath asphalt concrete pavement, brick pavement, concreter pavement and at grade concrete slabs, including sidewalks, curbs and gutters. Also where indicated apply soil sterilant below expansion and control joints and at areas where pipes, ducts or other features penetrate slabs.

B. Apply soil sterilant uniformly and at the rates recommended by the manufacturer.

C. Apply soil sterilant to prepared subgrade, or after installation of aggregate base as recommended by the manufacturer.
3.12 DISPOSAL

A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the District.

END OF SECTION
SECTION 31 23 33
UTILITY TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Excavation, bedding, and backfill of underground storm drain, sanitary sewer and water piping and associated structures.

B. The CONTRACTOR shall provide all materials, equipment, and labor necessary to perform and complete all utility earthwork as shown on the Drawings and as specified herein.

C. The work of this Section includes all utility earthwork required for construction of the project. Such earthwork shall include, but may not necessarily be limited to, the loosening, removing, loading, transporting, depositing, and compacting in its final location of all materials wet and dry, as required for the purposes of completing the work, which shall include, but not necessarily be limited to, the furnishing, placing, and removing of sheeting, shoring and bracing necessary to safely support the sides of all excavations; all pumping, ditching, draining and other required measures for the removal or exclusion of water from the excavation; the supporting of structures above and below the ground; all backfilling around structures and all backfilling of trenches and pits; the disposal of excess excavated materials; borrow of materials to make up deficiencies for fills; and all other incidental earthwork.

D. Hazardous materials shall be handled in accordance with all regulatory agency requirements. Asbestos cement pipe (ACP) exists within the project area and replacement of existing ACP is anticipated but shall be abandoned in place unless otherwise noted in the plans. The contractor shall make every attempt to protect all asbestos containing items during the execution of this contract. However, there will be instances where ACP or asbestos containing material will need to be removed, handled, cut, disturbed, or disposed of and the contractor shall comply with all local, state and federal regulations regarding construction activities near asbestos containing materials.

1.02 SECTION EXCLUDES

A. Drainage fill material and placement around subdrains.

B. Power, telecommunications, and low voltage scope of work.

1.03 RELATED DOCUMENTS

A. ASTM:
   1. C 33, Specification for Concrete Aggregates.
7. D 2487, Classification of Soils for Engineering Purposes.


C. Caltrans Standard Specifications:
   1. Section 19, Earthwork.
   2. Section 26, Aggregate Bases.

D. CAL/OSHA, Title 8.

1.04 RELATED SECTIONS

A. Section 31 11 00, Clearing and Grubbing.
B. Section 33 31 00, Sanitary Sewer System.
C. Section 33 41 00, Storm Drain System.
D. Section 33 46 00 Subdrainage.

1.05 DEFINITIONS

A. AC: Asphalt Concrete.
C. Bedding: Material from bottom of trench to bottom of pipe.
D. CDF: Controlled Density Fill.
E. DIP: Ductile Iron Pipe.
F. Initial Backfill: Material from bottom of pipe to 12-inches above top of pipe.
G. PCC: Portland Cement Concrete.
H. RCP: Reinforced Concrete Pipe.
I. Springline of Pipe: Imaginary line on surface of pipe at a vertical distance of ½ the outside diameter measured from the top or bottom of the pipe.
J. Subsequent Backfill: Material from 12-inches above top of pipe to subgrade of surface material or subgrade of surface facility or to finish grade.

K. Trench Excavation: Removal of material encountered above subgrade elevations and within horizontal trench dimensions.
   1. Authorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions as shown on plans or authorized by the Geotechnical Consultant.
   2. Unauthorized Trench Over-Excavation: Excavation below trench subgrade elevations or beyond indicated horizontal trench dimensions without authorization by the Geotechnical Consultant. Unauthorized excavation shall be without additional compensation.

L. Utility Structures:
   1. Storm Drain Manholes, vaults, etc.
   2. Sanitary sewer manholes, vaults, etc.
   3. Water vaults, etc.

1.06 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements

B. Product Data:
   1. Grading and quality characteristics showing compliance with requirements for the Work.
   2. Certify that material meets requirements of the Project.
   3. Aggregate for Structural Soil Mix.

C. Samples:
   1. If required by the Geotechnical Consultant, provide 40-pound samples of all imported trench bedding and backfill material sealed in airtight containers, tagged with source locations and suppliers of each proposed material. Do not import materials to Project without written approval of the Geotechnical Consultant.
   2. Provide materials from same source throughout work. Change of source requires approval of the Geotechnical Consultant and the District’s Representative’s.

D. Material Test Reports: Provide, from a qualified testing agency, the following test results showing compliance with the project requirements:
   1. Classification according to ASTM D 2487 of each imported trench bedding and backfill material.
   2. Laboratory compaction curve in conformance with ASTM D 1557 for each imported trench bedding and backfill material
   3. Structural Soil Mix Testing: Provide a two-gallon representative sample to laboratories for an analysis of the structural soil mix indicating the following:
      a. Particle size analysis, including the following gradients of mineral content (USDA Designated Size in mm):
         1) 3” (76mm)
         2) 2 ½” – 3” (63-76mm)
         3) 2” – 2 ½” (50-63mm)
         4) 1 ½” – 2” (37-50mm)
         5) 1” (25-37mm)
b. Provide manufacturer’s analysis of the following:
1) Loose and rodded unit weight.
2) Bulk specific gravity and absorbance.
3) Gravel dimension and surface texture description.
4) Aggregate soundness and L.A. abrasion.

c. Sample Collection Procedure:
1) Collect a minimum of eight samples to make up the composite sample.
2) Take samples from random locations in the stockpile varying from the top to the bottom and around the stockpile.
3) Take at least half the samples from the lower third of the stockpile into a clean bucket.
4) Thoroughly mix material after samples are taken.
5) Remove 2 gallon of material from bucket and fill a zip-lock plastic bag.
6) Double bag the composite sample and label the bag with a permanent marker indicating the material name and date sample was taken.

1.07 QUALITY ASSURANCE

A. Provide an independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock definition testing, as documented according to ASTM D 3740 and ASTM E 548.

B. Conform all work and materials to the recommendations or requirements of the Geotechnical Report and meet the approval of the Geotechnical Consultant.

C. Conform all work to the appropriate portion(s) of the Caltrans Standard Specifications, Section 19.

D. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM D 1557.

E. The Geotechnical Consultant will perform observations and tests required to enable him to form an opinion of the acceptability of the trench backfill. Correct the trench backfill that, in the opinion of the Geotechnical Consultant, does not meet the requirements of these Technical Specifications and the Geotechnical Report.

1.08 PROJECT CONDITIONS

A. Promptly notify the District’s Representative of surface or subsurface conditions differing from those disclosed in the Geotechnical Report. First notify the District’s Representative verbally to permit verification and extent of condition and then in writing. No claim for conditions differing from those anticipated in the Contract Documents and disclosed in the Geotechnical Report will be allowed unless Contractor has notified the District’s Representative in writing of differing conditions prior to contractor starting work on affected items.
B. Protect open, trenches, and utility structure excavations with fences, covers and railings to maintain safe pedestrian and vehicular traffic passage.

C. Stockpile on-site and imported backfill material temporarily in an orderly and safe manner.

D. Provide dust and noise control in conformance with Section 01 00 00, General Requirements.

E. Areas to receive structural soil mix shall be inspected by the Owner’s Representative before starting work.

PART 2 - PRODUCTS

2.01 PIPE BEDDING AND INITIAL BACKFILL

A. ASTM D 2321, Class IA, IB or II.
   1. Clean and free of clay, silt or organic matter.

B. Class 2 Aggregate Base: Conform to Section 26 of Caltrans Standard Specifications, ¾-inch maximum.


2.02 WARNING TAPE

A. See Section 33 11 66, Water Distribution System.

2.03 SUBSEQUENT BACKFILL

A. Conform to on-site or imported structural backfill in Section 31 23 00, Excavation and Fill.

2.04 CONTROLLED DENSITY FILL (CDF) (IN TRENCHES)

A. Provide non-structural CDF, from bottom of trench to finish subgrade of subbase or base material, that can be excavated by hand and produce unconfined compressive 28-day strengths from 50-psi to a maximum of 150-psi. Provide aggregate no larger than 3/8-inch top size. The 3/8-inch aggregate shall not comprise more than 30% of the total aggregate content.

B. Cement: Conform to the standards as set forth in ASTM C-150, Type II Cement.

C. Fly Ash: Conform to the standards as set forth in ASTM C-618, for Class F pozzolan. Do not inhibit the entrainment of air with the fly ash.

D. Air Entraining Agent: Conform to the standards as set forth in ASTM C-260.

E. Aggregates need not meet the standards as set forth in ASTM C-33. Any aggregate, producing performances characteristics described herein will be accepted for
consideration. The amount of material passing a #200 sieve shall not exceed 12% and no plastic fines shall be present.

F. Provide CDF that is a mixture of cement, Class F pozzolan, aggregate, air entraining agent and water. CDF shall be batched by a ready mixed concrete plant and delivered to the job site by means of transit mixing trucks.

G. The Contractor shall determine the actual mix proportions of the controlled density fill to meet job site conditions, minimum and maximum strengths, and unit weight. Entrained air content shall be a minimum of 4.0%. The actual entrained air content shall be established for each job with the materials and aggregates to be used to meet the placing and unit weight requirements. Entrained air content may be as high as 20% for fluidity requirements.

H. Mix design shall meet the Geotechnical Consultant’s approval.

2.05 CONCRETE STRUCTURE BEDDING AND BACKFILL

A. Precast Structures: Same materials to the same heights as specified for pipe bedding and backfill, or other material approved by the Geotechnical Consultant.

B. Poured-in-Place Structures:
   1. Bedding: Bedding shall meet the approval of the Geotechnical Consultant. In general, bedding is not required, pour bases against undisturbed native earth in cut areas and against engineered fill compacted to 90% relative compaction in embankment areas.
   2. Side Backfill: On-site or imported structural fill meeting the requirements given in Section 31 23 00.
   3. Structural Soil Mix: TMT Enterprices, 1996 Oakland Road, San Jose, CA 915131; (408)432-9010

2.06 AGGREGATE FOR STRUCTURAL SOIL MIX:

A. Aggregate shall be triangular.

B. Aggregate shall not be limestone or sandstone.

C. Aggregate shall pass a 3-inch screen and be retained on a 2-inch screen.

D. Aggregate dimensions shall not exceed 1.5:1.0 for any two dimensions chosen.

2.07 SOIL FOR STRUCTURAL SOIL MIX:

A. Soil shall be a “clay loam” or “clay” based on “USDA classification system” as determined by mechanical analysis and shall be of uniform composition, without admixture of subsoil.

B. Soil shall be free of stones greater than one-half inch, plants, roots, debris and other extraneous matter larger than one inch in diameter or an excess of smaller pieces of same type materials as determined by Owner’s Representative.
C. Soil shall not contain toxic substances harmful to plant growth.

D. Soil shall be obtained from naturally well drained areas which have never been stripped of topsoil before and have a history of satisfactory vegetative growth.

E. Soil shall contain not less than 3% or more than 7% organic matter as determined by organic carbon and total nitrogen on oven-dried samples.

F. Soil shall be the product of a commercial processing facility specializing in production of Structural Soil Mixes for a minimum of 5 years.

G. Mechanical analysis:
   1. Textural Class: Based on material passing a 2 mm screen.
   2. Gravel: Less than 5%.
   3. Sand: 20 – 50%.
   4. Silt: 20 – 30%.
   5. Clay: 25- 60%.

H. Chemical analysis:
   1. pH: Between 6.5 to 7.9.
   3. Nutrient level:
      a. Fertility: The range of the essential elemental concentration in soil shall be as follows.

         Ammonium Bicarbonate/DTPA Extraction parts per million (mg/kolgram) dry weight basis.

         Phosphorous  10-40
         Potassium   100-200
         Iron        5-35
         Manganese  0.6-6
         Zinc        1-8
         Copper      0.3-5
         Boron       0.2-1
         Magnesium  50-150
         Sodium     0-100
         Sulfur     25-500
         Molybdenum 0.1-2

      b. Toxic elements and compounds and excessive nutrients below UC guidelines and soil testing laboratory guidelines. The maximum permissible elemental concentration in the soil.

         Ammonium Bicarbonate/DTPA Extraction parts per million (mg/kolgram) dry weight basis.

         Arsenic   1
         Cadmium   1
         Chromium 10
         Cobalt    2
2.08 STRUCTURAL SOIL MIX

A. Content:
1. 4 parts structural soil aggregate.
2. 1 part soil, treated with polymer.

B. Mixing:
1. Mix polymer (PAM) with soil 48 hours ahead of blending with aggregate to allow for proper bonding.
2. Cure polymer treated soil by allowing the soil to partially dry.
3. Based upon accepted mix design, blend materials off-site in a clean area using an experienced blending operator.
4. Uniformly blend materials so that they are even distributed throughout mixtures.
5. Maintain adequate soil moisture content during mixing process.
6. Soils and mix components shall easily shred and break down without clumping.
7. Soil clods shall easily break down into a medium crumbly texture material.
8. Do not blend materials that are saturated or contain excessive water.
9. Measure and monitor amount of soils moisture at mixing site periodically during mixing process.
10. Protect materials and mixtures from contamination prior to, during, and after mixing operations.
11. Store mixes in stockpiles prior to shipment to site in clean areas protected from contamination from other materials.
12. Reblend the mix if the components have separated.

2.09 FILTER FABRIC

A. Filter Fabric:
2. Mirifi 140N (Mirifi Inc., Charlotte, NC) (Tel. 800-438-1855) or equal.

PART 3 - EXECUTION

3.01 TRENCHING AND EXCAVATION

A. Existing PCC or AC Areas: Cut PCC or AC to full depth at a minimum distance of 12-inches beyond the edge of the trench.
B. Excavate by hand or machine. For gravity systems begin excavation at the outlet end and proceed upstream. Excavate sides of the trench parallel and equal distant from the centerline of the pipe. Hand trim excavation. Remove loose matter.

C. Excavation Depth for Bedding: Minimum of 4-inches below bottom of pipe or as otherwise allowed or required by the Geotechnical Consultant, except that bedding is not required for nominal pipe diameters of 2-inches or less.

D. Excavation Width at Springline of Pipe:
   1. Up to a nominal pipe diameter of 24-inches: Minimum of twice the outside pipe diameter, or as otherwise allowed or required by the Geotechnical Consultant.
   2. Nominal pipe diameter of 30-inches through 36-inches: Minimum of the outside pipe diameter plus 2-feet, or as otherwise allowed or required by the Geotechnical Consultant.
   3. Nominal pipe diameter of 42-inches through 60-inches: Minimum of the outside pipe diameter plus 3-feet, or as otherwise allowed or required by the Geotechnical Consultant.

E. Over-Excavations: Backfill trenches that have been excavated below bedding design subgrade, with approved bedding material.

F. Comply with the District’s Representative’s limitations on the amount of trench that is opened or partially opened at any one time. Do not leave trenches open overnight without the approval of the District’s Representative.

G. Where forming is required, excavate only as much material as necessary to permit placing and removal of forms.

H. Bottoms of trenches will be subject to testing by Geotechnical Consultant. Correct deficiencies as directed by the Geotechnical Consultant.

I. Grade bottom of trench to provide uniform thickness of bedding material and to provide uniform bearing and support for pipe along entire length. Remove stones to avoid point bearing.

3.02 CONTROL OF WATER AND DEWATERING

A. Be solely responsible for dewatering trenches and excavations and subsequent control of ground and surface water. Provide and maintain such pumps or other equipment as may be necessary to control ground water and seepage to the satisfaction of the Geotechnical Consultant and the District’s Representative until backfilling is completed.

B. Dewater during backfilling operation so that groundwater is maintained at least one foot below level of compaction effort.

C. Obtain the Geotechnical Consultant’s approval for proposed control of water and dewatering methods.

D. Reroute surface water runoff away from open trenches and excavations. Do not allow water to accumulate in trenches and excavations.
E. Maintain dewatering system in place until dewatering is no longer required.

3.03 BRACING AND SHORING

A. Conform to California and Federal OSHA requirements.

B. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the pipes and appurtenances being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.

C. Be solely responsible for all bracing and shoring and, if requested by the District’s Representative, submit details and calculations to the District’s Representative. The District’s Representative may forward the submittal to the Geotechnical Consultant, the Consulting Engineer and/or the California Division of Industrial Safety for their review. The Contractor’s submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer registered in California. No excavations in trench section or around structures shall precede a response to the submittal by the District’s Representative.

D. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the line, grade, or backfill compaction or operation of the utility being installed or adjacent utilities and facilities.

3.04 PIPE BEDDING

A. Obtain approval of bedding material from the Geotechnical Consultant.

B. Accurately shape bedding material to the line and grade called for on the Plans. Carefully place and compact bedding material to the elevation of the bottom of the pipe in layers not exceeding 8-inches in loose thickness. Compact bedding material at optimum water content to 90% relative compaction for sand and 95% relative compaction for fine gravel unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of bedding material will not be permitted.

C. Upon completion of bedding operations, and prior to the installation of pipe, notify the Geotechnical Consultant, who will inspect the bedding layer. Do not commence pipe laying until the Geotechnical Consultant has approved the bedding.

3.05 WARNING TAPE

A. Install in accordance with Section 33 11 66.

3.06 BACKFILLING

A. Obtain approval of backfill material from Geotechnical Consultant.
B. Bring initial backfill up simultaneously on both sides of the pipe, so as to prevent any displacement of the pipe from its true alignment. Carefully place and compact initial backfill material to an elevation of 12-inches above the top of the pipe in layers not exceeding 8-inches in loose thickness. Compact initial backfill material at optimum water content to 90% relative compaction for sand and 95% relative compaction for fine gravel unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of initial backfill material will not be permitted.

C. Bring subsequent backfill to subgrade or finish grade as indicated. Carefully place and compact subsequent backfill material to the proper elevation in layers not exceeding 8-inches in loose thickness. Compact subsequent backfill material at optimum water content to 90% relative compaction, except in areas subject to vehicular traffic shall be compacted to at least 95% relative compaction, unless specified otherwise on the Plans or by the Geotechnical Consultant. Compact by pneumatic tampers or other mechanical means approved by the Geotechnical Consultant. Jetting or ponding of subsequent backfill material will not be permitted.

D. Do not use compaction equipment or methods that produce horizontal or vertical earth pressures which may cause excessive pipe displacement or damage the pipe.

E. Utility backfill shall be inspected and tested by the Geotechnical Consultant during placement. Cooperate with the Geotechnical Consultant and provide working space for such tests in operations. Backfill not compacted in accordance with these specifications shall be re-compacted or removed as necessary and replaced to meet the specified requirements, to the satisfaction of the Geotechnical Consultant and the District’s Representative prior to proceeding with the Project.

3.07 STRUCTURAL SOIL MIX INSTALLATION

A. Place mix carefully to avoid damage or displacement of other materials such as paving, drain rock, geotextile fabric and irrigation piping.

B. Do not mix subgrade soils on construction materials with mix.

C. Remove soil mix contaminated with subgrade soil, construction materials or debris.

D. Maintain mix in a moist, but not saturated, condition to prevent segregation of mix during placement.

E. Install mix in 6 inch lifts in locations indicated on the Drawings.

F. Compact lifts to 95 percent compaction in compliance with Geotechnical Investigation Report. Schedule the Geotechnical Engineer to perform nuclear density field tests after each lift of mix to confirm compaction.

G. Install final lift of mix to elevations indicated on the Drawings.
A. Upon completion of utility earthwork all lines, manholes, catch basins, inlets, water meter boxes and other structures shall be thoroughly cleaned of dirt, rubbish, debris and obstructions of any kind to the satisfaction of the District's Representative.
SECTION 31 25 00
EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 SUMMARY
A. This Section describes the requirements for providing and installing temporary erosion and sedimentation control structures as specified.

1.2 SUBMITTALS
A. Follow Submittal procedure outlined in Section 1 General Provisions.

1.3 REGULATORY REQUIREMENTS:
B. State Water Resources Control Board (SWRCB) standards.

PART 2 - PRODUCTS

2.1 Furnish and install products to eliminate potential erosion and sedimentation during construction works. Products which shall be installed, but are not limited to, are the following:
A. Siltation fences
B. Outlet structure, basins, ditches
C. Filter fabric, and/or mesh
D. Hydroseeding
E. Wattle and/or Gravel bags

PART 3 - EXECUTION

3.1 GENERAL
A. The Contractor shall review the BMP’s selected for the Project.
B. Erosion and sedimentation control measures are to be installed in areas only to extent required by new construction and as indicated or as directed by governing regulations.
C. The Contractor shall provide inspection and repair BMP’s throughout the construction process.
END OF SECTION
PART 1 - GENERAL

1.0 SECTION INCLUDES

  A. Aggregate and aggregate grading for Portland cement concrete.
  B. Water for Portland cement concrete.
  C. Admixtures for Portland cement concrete.
  D. Proportioning for Portland cement concrete.
  E. Mixing and transporting Portland cement concrete.
  F. Formwork for cast in place Portland cement concrete.
  G. Embedded materials for Portland cement concrete.
  H. Steel reinforcement for Portland cement concrete.
  I. Placing and finishing Portland cement concrete.
  J. Curing Portland cement concrete.
  K. Protecting Portland cement concrete.

1.1 RELATED SECTIONS

. Section 31 11 00, Clearing and Grubbing

1.2 RELATED DOCUMENTS

. ASTM:
  1. A 82, Cold Drawn Steel Wire for Concrete Reinforcement.
  2. A 185, Steel Welded Wire Fabric, Plain for Concrete Reinforcement.
  3. A 615, Deformed and Plain Billet Steel Bars, for Concrete Reinforcement.
  7. C 618, Fly Ash and Raw or Calcined Natural Pozzolan for use as Natural Admixture in Portland Cement.

A. Caltrans Standard Specifications:
   1. Section 51: Concrete Structures.
   2. Section 73: Concrete Curbs and Sidewalks.
   3. Section 90: Concrete.

1.3 DEFINITIONS

   . ASTM: American Society for Testing Materials

1.4 SUBMITTALS

   . Submittal procedure shall be as directed by the District's General Requirements.

   A. Concrete Mix Design: Have all concrete mixes designed by a testing laboratory and approved by the Consulting Engineer. Conform all mixes to the applicable building code requirement, regardless of other minimum requirements listed herein or on the drawings. Submit mix designs for review before use. Show proportions and specific gravities of cement, fine and coarse aggregate, and water and gradation of combined aggregates.

1.5 QUALITY ASSURANCE

   . Concrete shall be subject to quality assurance in accordance with Section 90 of Caltrans Standard Specifications.
   1. Slump tests: Have available, at job site, equipment required to perform slump tests. Make one slump test for each cylinder sample, from same concrete batch. Allowable maximum slump shall be 4 inches for walls and 3 inches for slab on grade.

   A. Certifications:
   1. Provide District’s Representative at the time of delivery with certificates of compliance signed by both Contractor and Supplier containing the following statements:
      a. Materials contained comply with the requirements of the Contract Documents in all respects.
      b. Proportions and mixing comply with the design mix approved by the Consulting Engineer. Design mix shall have been field tested in accordance with the herein requirements of the Caltrans Standard Specifications and produces the required compressive strength under like conditions.
      c. Statement of type and amount of any admixtures.
   2. Provide District’s Representative, at time of delivery, with certified delivery ticket stating volume of concrete delivered and time of mixing, or time of load-out in case of transit mixers.
B. Conform to the applicable provisions of Section 51, 73 and 90 of the Caltrans Standard Specification and these Technical Specifications.
   1. Conform construction of Portland cement concrete surface improvements (including curbs, gutters, medians, valley gutters, walks, pads) to the requirements of Section 73 of the Caltrans Standard Specifications unless otherwise required in these Technical Specifications or shown on the Plans.
   2. Conform other construction of Portland cement concrete items to the requirements of Section 51 of the Caltrans Standard Specifications unless otherwise required in these Technical Specifications or shown on the Plans.

1.6 DESIGNATION
   . General: Whenever the 28-day compressive strength is designated herein or on the Plans is a 3,600psi or greater, the concrete shall considered to be designated by compressive strength. The 28-day compressive strength shown herein or on the plans which are less than a 3,600psi are shown for design information only and are not considered a requirement for acceptance of the concrete. Whenever the concrete is designated by class or as minor concrete herein or on the Plans, the concrete shall contain the cement per cubic yard shown in Section 90-1.01 of the Caltrans Standard Specifications.
   A. Unless noted otherwise herein or on the Plans, the minimum compressive strength for portland cement concrete at 28 days for this Project shall be 3,600 psi.

PART 2 - PRODUCTS

2.0 PORTLAND CEMENT
   . General: Type II (modified) cement conforming to section 90-2.01 of the Caltrans Standard Specifications.
   A. Provide a coloring equivalent to ¼ pound of lampblack per cubic yard. Add to the concrete at the central mixing plant. Liquiblack concrete colorant, or approved equal, may be used in lieu of lampblack. One pint of Liquiblack shall be considered equal to one pound of lampblack.

2.1 AGGREGATE AND AGGREGATE GRADING
   . General: Conform to the requirements of Section 90-2.02, 2.02A and 2.02B of the Caltrans Standard Specifications.
   A. Aggregate Size and Gradation: Conform to the requirements of Section 90-3 of the Caltrans Standard Specifications for 1-inch maximum combined aggregate.

2.2 WATER
2.3 EXPANSION JOINT MATERIAL

Material for expansion joints in Portland cement concrete improvements shall be pre-molded expansion joint fillers conforming to the requirements of ASTM Designation D 1751. Expansion joint material shall be shaped to fit the cross section of the concrete prior to being placed. Suppliers certificates showing conformance with this specification shall be delivered with each shipment of materials delivered to the job site. Unless noted otherwise herein or on the Plans expansion joint thickness shall be as follows:
2. Gutter Lining, Ditch Lining and Channel Lining: ½-inch.
3. Structures: As indicated.

2.4 REINFORCEMENT AND DOWELS

Bar reinforcement for concrete improvements shall be deformed steel bars of the size or sizes called for on the plans conforming to the requirements of ASTM Designation A 615 for Grade 60 bars. Size and shape for bar reinforcement shall conform to the details shown or called for on the Plans. Substitution of wire mesh reinforcement for reinforcing bars will not be allowed.

A. Slip dowels, where noted or called for on the plans or detail drawings shall be smooth billet-steel bars as designated and conforming to the requirements of ASTM Designation A 615 for Grade 60 bars. Ends of bars inserted in new work shall be covered with a cardboard tube sealed with cork; no grease or oil shall be used.

B. Mesh for reinforcement for concrete improvements shall be cold drawn steel wire mesh of the size and spacing called for on the plans conforming to the requirements of ASTM Designation A 82 for the material and ASTM Designation A 185 for the mesh. Size and extent of mesh reinforcement shall conform to the details shown or called for on the plans.

C. Tie wire for reinforcement shall be eighteen (18) gauge or heavier, black, annealed conforming to the requirements of ASTM Designation A 82.

D. Suppliers certificates showing conformance with this specification shall be delivered with each shipment of materials delivered to the job site.

2.5 ACCESSORY MATERIALS

Conform water stops and other items required to be embedded in of portland cement concrete structures to the applicable requirements of Section 51 of the

HMC Architects
HMC Architects

Caltrans Standard Specifications unless otherwise specifically noted or called for on the Plans or detail drawings.

A. Curing Compounds:
   1. Regular Portland Cement Concrete: "Non-Pigmented Curing Compound - Chlorinated Rubber Base-Clear" conforming to the requirements contained in Section 90-7.01B, of the Caltrans Standard Specifications.

2.6 FORMS
   . Conform to the requirements of Section 51-1.05 of the Caltrans Standard Specifications.

2.7 PRECAST CONCRETE STRUCTURES
   . Conform to the following Sections of Caltrans Standard Specifications:
     1. 51-1.02, Minor Structures.
     2. 70-1.02C, Flared End Sections.
     3. 70-1.02H, Precast Concrete Structures.

PART 3 - EXECUTION

3.0 STRUCTURAL EXCAVATION

   Structural excavation may be either by hand, or by machine and shall be neat to the line and dimension shown or called for on the plans. Excavation shall be sufficient width to provide adequate space for working therein, and comply with CAL-OSHA requirements.

A. Where an excavation has been constructed below the design grade, refill the excavation to the bottom of the excavation grade with approved material and compact in place to 95% of the maximum dry density.

B. Remove surplus excavation material remaining upon completion of the work from the job site, or condition it to optimum moisture content and compact it as fill or backfill on the site, if the material is approved by the Geotechnical Consultant.

3.1 SOIL STERILANT

   Furnish and apply to areas indicated in accordance with Section 31 23 00, Excavation and Fill.

3.2 BRACING AND SHORING
Conform to California and Federal OSHA requirements.

A. Place and maintain such bracing and shoring as may be required to support the sides of the excavations for the proper protection of workmen; to facilitate the work; to prevent damage to the facility being constructed; and to prevent damage to adjacent structures or facilities. Remove all bracing and shoring upon completion of the work.

B. Be solely responsible for all bracing and shoring and, if requested by the District’s Representative, submit details and calculations to the District’s Representative. The District’s Representative may forward the submittal to the Geotechnical Consultant, the Consulting Engineer and/or the California Division of Industrial Safety for their review. The Contractor's submittal shall include the basic design, assumed soils conditions and estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used, and shall be prepared by a civil engineer or structural engineer registered in California. No excavations related to the proposed facility shall precede a response to the submittal by the District's Representative.

C. Be solely responsible for installing and extracting the sheathing in a manner which will not disturb the position or operation of the facility being constructed or adjacent utilities and facilities.

3.3 PLACING CONCRETE FORMS

A. Thoroughly clean all forms prior to placement and coat forms with approved form oil in sufficient quantity to prevent adherence of concrete prior to placing concrete.

B. Carefully set forms to the alignment and grade established and conform to the required dimensions. Rigidly hold forms in place by stakes set at satisfactory intervals. Provide sufficient clamps, spreaders and braces to insure the rigidity of the forms.

C. Provide forms for back and face of curbs, lip of gutters and edge of walks, valley gutters or other surface slabs that are equal to the full depth of the concrete as shown, noted or called for on the Plans. On curves and curb returns provide composite forms made from benders or thin planks of sufficient ply to ensure rigidity of the form.

3.4 PLACING STEEL REINFORCEMENT

Bars shall be free of mortar, oil, dirt, excessive mill scale and scabby rust and other coatings of any character that would destroy or reduce the bond. All bending shall be done cold, to the shapes shown on the plans. The length of lapped splices shall be as follows:
1. Reinforcing bars No. 8, or smaller, shall be lapped at least 45 bar diameters of the smaller bar joined, and reinforced bars Nos. 9, 10, and 11 shall be lapped at least 60 bar diameters of the smaller bars joined, except when otherwise shown on the plans.

2. Splice locations shall be made as indicated on the plans.

   A. Accurately place reinforcement as shown on the plans and hold firmly and securely in position by wiring at intersections and splices, and by providing precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under applied loads. Provide supports and ties of such strength and density to permit walking on reinforcing without undue displacement.

   B. Place reinforcing to provide the following minimum concrete cover:
      1. Surfaces exposed to water: 4-inches.
      2. Surfaces poured against earth: 3-inches.
      3. Formed surfaces exposed to earth or weather: 2-inches.
      4. Slabs, walls, not exposed to weather or earth: 1-inch.

   C. Minimum spacing, center of parallel bars shall be two and one half (2-1/2) times the diameter of the larger sized bar. Accurately tie reinforcing securely in place prior to pouring concrete. Placing of dowels or other reinforcing in the wet concrete is not permitted.

3.5 MIXING AND TRANSPORTING PORTLAND CEMENT CONCRETE

   A. Do not hand mix concrete for use in concrete structures

3.6 PLACING PORTLAND CEMENT CONCRETE

   A. Do not place concrete until the subgrade and the forms have been approved.

   B. Convey concrete from mixer to final location as rapidly as possible by methods that prevent separation of the ingredients. Deposit concrete as nearly as possible in final position to avoid re-handling.

   C. Place and solidify concrete in forms without segregation by means of mechanical vibration or by other means as approved by the District's Representative. Continue vibration until the material is sufficiently consolidated and absent of all
voids without causing segregation of material. The use of vibrators for extensive shifting of fresh concrete will not be permitted.

D. Concrete in certain locations may be pumped into place upon prior approval by the District’s Representative. When this procedure requires redesign of the mix, such redesign shall be submitted for approval in the same manner as herein specified for approval of design mixes.

3.7 PLACING ACCESSORY MATERIALS

. Place water stops and other items required to be embedded in of Portland cement concrete structures at locations shown or required in accordance with Section 51 of the Caltrans Standard Specifications unless otherwise specifically noted or called for on the Plans.

A. Curing Compounds:
  1. Regular Portland Cement Concrete: Apply “Non-Pigmented Curing Compound - chlorinated Rubber Base-Clear” in accordance with Section 90-7.01B, 7.01D and 7.03 of the Caltrans Standard Specifications.

3.8 EXPANSION JOINTS

. Construct expansion joints incorporating pre-molded joint fillers at twenty (20) foot intervals in all concrete curbs, gutters, sidewalks, median/island paving, valley gutters, driveway approaches and at the ends of all returns. At each expansion joint install one-half inch by twelve inch (1/2" x 12") smooth slip dowels in the positions shown or noted on the detail drawings.

A. Orient slip dowels at right angles to the expansion joint and hold firmly in place during the construction process by means of appropriate chairs.

3.9 WEAKENED PLANE JOINTS

. Construct weakened plane joints in concrete curbs, gutters, sidewalks, median/island paving and valley gutters between expansion joints at ten (10) foot intervals throughout, or as otherwise indicated. Depth of joint score depth to be one-fourth (25%) the thickness of the concrete.

1. Grooved Joints: Form weakened plane joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8-inch. Repeat grooving of weakened plane joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

2. Sawed Joints: Form weakened plane joints with power saws equipped with shatterproof abrasive or diamond-rimed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade or otherwise damage surface and before concrete develops random contraction cracks.

3.10 FORM REMOVAL

HMC Architects
. Remove forms without damage to the concrete. Remove all shores and braces below the ground surface, before backfilling.

A. Do not backfill against concrete until the concrete has developed sufficient strength to prevent damage.

B. Leave forms for cast-in-place walls in place at least 72 hours after pouring.

C. Leave edge forms in place at least 24 hours after pouring.

3.11 CONSTRUCTION

. Form, place and finish concrete curbs, walkways, island paving, valley gutters and driveway approaches in conformance with the applicable requirements of Section 73-1.04, 73-1.05, 72-1.05A and 73-1.06 of the Caltrans Standard Specifications as modified herein.

A. Provide a medium broom finish to all horizontal surfaces unless otherwise shown.

B. Construct new concrete curb, curb and gutter and valley gutters against existing asphalt concrete by removing a minimum of 12-inches of the asphalt concrete to allow placement of curb or gutter forms. Patch pavement with a 6-inch deep lift of asphalt concrete after gutter form is removed.

C. Where monolithic curb, gutter and sidewalk is specified, separate concrete pours will not be allowed.

3.12 CONNECTING TO EXISTING CONCRETE IMPROVEMENTS

. New curb, gutter, or sidewalk is to connect to existing improvements to remain by saw cutting to existing sound concrete at the nearest score line, expansion joint or control joint. Drill and insert ½-inch diameter by 12-inch long dowels at 24-inches on center into existing improvements. Install pre-molded expansion joint filler at the matching joint.

A. A cold joint to the existing curb is not acceptable.

3.13 DECORATIVE AND NON-DECORATIVE SURFACING CONSTRUCTION

. Decorative surfacing concrete walks or other installations shall be formed and placed as a concrete slab conforming to the details shown or noted on the Plans. Exposed aggregate concrete sidewalks shall be repaired in kind or better condition.

A. Add lampblack or equivalent to the non-decorative surface concrete at the central mixing plant.
3.14 ACCESSIBLE PATH OF TRAVEL CONSTRUCTION FINISH

- Provide equivalent of medium salted finish at slopes less than 6% and slip-resistant finish at slopes 6% and greater along any accessible path of travel.

3.15 FIELD QUALITY CONTROL

- Finish subgrade for concrete improvements shall be subject to approval prior to placement of forms.

A. No concrete shall be placed prior to approval of forms.

B. Concrete improvements constructed shall not contain areas that pond water and shall be smooth and ridge free.

C. Conform the finish grade at top of curb, flow line of gutter, and the finish cross section of concrete improvements to the design grades and cross sections.

D. Variation of concrete improvements from design grade and cross section as shown or called for on the plans shall not exceed the tolerances established in Sections 73-1.05 and/or 73-1.06 of the Caltrans Standard Specifications.

3.16 RESTORATION OF EXISTING IMPROVEMENTS

- Replace in kind all pavement or other improvements removed or damaged due to the installation of concrete improvements.

A. Remove, landscaping or plantings damaged or disturbed due to the installation of concrete improvements. Replace in kind.

END OF SECTION
SECTION 32 11 32
AGGREGATE BASE COURSE

PART 1  GENERAL

1.1  SECTION INCLUDES
A. Aggregate base.
B. Lime stabilization.

1.2  RELATED SECTIONS
A. Section 32 12 16, Asphalt Paving.
B. Section 32 05 23, Portland Cement Concrete

1.3  RELATED DOCUMENTS
A. Geotechnical Report: “Geotechnical Investigation for Proposed Physical Education Complex (D-4012)” Diablo Valley College, 321 Golf Club Road, Pleasant Hill, CA, prepared by RMA Group, November 16, 2017
B. Caltrans Standard Specifications:
   1. Section 24, Lime Stabilization.
   2. Section 26, Aggregate Bases.
C. ASTM:
   1. D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

1.4  DEFINITIONS

1.5  SUBMITTALS
A. Submittal procedure shall be as outlined in the District’s General Requirements.
B. Submit material certificates signed by the material producer and the Contractor, certifying that that each material item complies with, or exceeds the specified requirements.

1.6  QUALITY ASSURANCE
A. Conform to these Specifications and Section 19 of Caltrans Standard Specifications.

B. Finish surface of the prepared subgrade to receive aggregate base, shall be as specified in Section 31 23 00.

C. Finish surface of material to be stabilized prior to lime treatment shall be as specified in Section 24-1.04 of Caltrans Standard Specifications.

D. Finish surface of the stabilized material after lime treatment shall be as specified in Section 24-1.08 of Caltrans Standard Specifications.

E. Do not project the finish surface of aggregate base above the design subgrade.

F. Finish surface of aggregate base shall be 0 to - 0.05-feet.

G. Finish surface of cement treated base shall be as specified in Section 27 of Caltrans Standard Specifications.

H. Percentage of compaction specified shall be the minimum acceptable. The percentage represents the ratio of the dry density of the compacted material to the maximum dry density of the material as determined by the procedure set forth in ASTM Designation D1557.

PART 2 PRODUCTS

2.1 FILL MATERIAL

A. If fill material is required to restore the previously constructed subgrade to its proper elevation, provide structural fill material specified in Section 31 23 00.

2.2 AGGREGATE BASE

   1. Class 2, 3/4-inch Maximum: Section 26-1.02A.

2.3 LIME STABILIZATION

A. Lime Treatment Material per Geotechnical recommendation and field investigation if required.

PART 3 EXECUTION

3.1 SOIL STERILANT

A. Furnish and apply to areas indicated in accordance with Section 31 23 00.
3.2 AGGREGATE BASE
   A. Watering, Spreading & Compacting: Section 26-1.035, 26-1.04 and 26-1.05 of Caltrans Specs

3.3 LIME STABILIZATION
   A. Performing the stabilization shall conform with Geotechnical recommendation

END OF SECTION
SECTION 32 12 16
ASPHALT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Prime coat.
B. Tack coat.
C. Asphalt concrete paving.
D. Asphalt concrete overlay.
E. Asphalt curbs.
F. Pavement grinding.
G. Adjusting manholes, valves, monument covers and other structures to grade.

1.2 RELATED SECTIONS

A. Section 32 11 32, Aggregate Base.

1.3 RELATED DOCUMENTS

A. ASTM:

B. Caltrans Standard Specifications.
1. Section 39: Asphalt Concrete.
2. Section 88: Engineering Fabrics.
4. Section 93: Liquid Asphalts.
5. Section 94: Asphaltic Emulsions.

1.4 DEFINITIONS


1.5 QUALITY ASSURANCE

A. Testing Agency: District’s Representative will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports.
1. Testing agency will conduct and interpret tests and state in each report whether tested work complies with or deviates from specified requirements.

B. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with specified requirements.

C. Thickness of Asphalt Concrete: In-place compacted thickness of asphalt courses will be determined according to ASTM D 3549.

D. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D 979.
1. Reference maximum theoretical density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
2. In-place density of compacted pavement may be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
   a. One core sample may be taken for every 1000 sq. yd. or less of installed pavement, but in no case will fewer than 3 cores be taken.
   b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

1.6 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements.

B. Job-Mix Designs: Certificates signed by manufacturers certifying that each asphalt concrete mix complies with requirements.

C. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

1.7 PROJECT CONDITIONS
A. Environmental Limitations:
   1. Prime Coat: Minimum surface temperature of 60 deg F at application.
   2. Tack Coat: Minimum surface temperature of 60 deg F at application.
   3. Asphalt Concrete: Minimum atmospheric temperature of 50 deg F at application.
   4. Reinforcing Fabric: Air temperature is 50 deg F and rising and pavement temperature is 40 deg F and rising.

PART 2 - PRODUCTS

2.1 ASPHALT CONCRETE

A. Caltrans Standard Specifications Section 39, Type B.

B. Asphalt Materials:
   3. Tack Coat: Caltrans Standard Specification Section 94, SS1 or SS1h.


F. Sand: ASTM D 1073, Grade No. 2 or 3.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

B. Proof-roll subbase using heavy pneumatic-tired rollers to locate areas that are unstable or that require further compaction.

C. Notify District’s Representative in writing of any unsatisfactory conditions. Do not begin paving until these conditions have been satisfactorily corrected.

3.2 PAVEMENT GRINDING

A. Clean existing paving surface of loose or deleterious material immediately before pavement grinding.
B. Grind conforms as indicated.

3.3 SURFACE PREPARATION FOR AGGREGATE BASE MATERIALS

A. General: Immediately before placing asphalt materials remove loose and deleterious material from substrate surfaces and ensure that prepared subgrade is ready to receive paving according to the Caltrans Standard Specification Section 39-4.01.

B. Prime Coat: Apply uniformly over surface of compacted-aggregate base according to the Caltrans Standard Specification Section 39-4.02. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure for 24 hours minimum.
1. If prime coat is not entirely absorbed within 8 hours after application, spread excess prime coat with hand tools and broadcast sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to all vertical surfaces against which asphalt concrete is to be placed, including existing surfaces of previously constructed asphalt or portland cement concrete paving and to surfaces abutting or projecting into new asphalt pavement, according to the Caltrans Standard Specification Section 39-4.02.
1. Allow tack coat to cure undisturbed before paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 SURFACE PREPARATION FOR PAVEMENT AT ASPHALT CONCRETE OVERLAYS

A. Pavement Irregularities: Level with asphalt concrete, Type B, No. 4 maximum.

B. Pavement Cracks:
1. Less than ¼-inch wide: Clean of all dirt by compressed air jet, spray and seal with RS-1 asphaltic emulsion.
2. Wider than ¼-inch: Clean of all dirt by compressed air jet, spray and seal with RS-1 asphaltic emulsion and skin patch.

C. Clean surface of all material, such as leaves, dirt, sand, gravel, water and vegetation prior to applying binder of paving asphalt to existing surface.

3.5 PAVEMENT REINFORCING FABRIC

A. Protect from exposure to ultraviolet rays until placed.

B. Reject rolls with broken or damaged cores, or factory wrinkled fabric that prevents
wrinkle free placement.

C. Place with binder of paving asphalt in accordance with Section 39-4.03 of Caltrans Standard Specifications.

### 3.6 ASPHALT CONCRETE SPREADING AND COMPACTING EQUIPMENT

A. Spreading Equipment: Caltrans Standard Specification Section 39-5.01.


### 3.7 ASPHALT CONCRETE PLACEMENT

A. Place, spread and compact asphalt concrete to required grade, cross section, and thickness according to the Caltrans Standard Specification Sections 39-6.01, 39-6.02 and 39-6.03.

B. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

### 3.8 JOINTS

A. Construct joints to ensure continuous bond between adjoining paving sections according to the Caltrans Standard Specification Sections 39-6.01 and 39-6.02.

1. Construct joints free of depressions with same texture and smoothness as other sections of asphalt course.
2. Clean contact surfaces and apply tack coat.
3. Offset longitudinal joints in successive courses a minimum of 6 inches.
4. Offset transverse joints in successive courses a minimum of 24 inches.
5. Compact joints as soon as asphalt concrete will bear roller weight without excessive displacement.

### 3.9 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact according to the Caltrans Standard Specification Sections 39-6.01 and 39-6.03.

B. Compaction Requirements: Average Density to be 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.

C. Finish Rolling: Finish roll paved surfaces to remove roller marks while asphalt is still warm.
D. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while still hot, with back of rake or smooth iron. Compact thoroughly using tamper or other satisfactory method.

E. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh asphalt. Compact by rolling to specified density and surface smoothness.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.10 ASPHALT CURBS

A. Construction: Place over compacted surfaces according to Caltrans Standard Specification Section 39-7.01 as specified for dikes. Apply a light tack coat prior to construction, unless pavement surface is still tacky and free of dust.

B. Shape: Place asphalt concrete to curb cross section indicated.

3.11 ADJUSTING MANHOLES, VALVES, MONUMENT COVERS AND OTHER STRUCTURES TO GRADE

A. Remove pavement, using vertical cuts, as needed to remove frame and provide for concrete collar. Do not damage adjacent pavement.
   1. Circular Covers: Cut circle with radius 6 inches larger than cover and concentric with cover.
   2. Rectangular Covers: Cut rectangle 6 inches larger than cover on all sides.

B. Install grade rings or blocking as needed to raise cover to finish grade.

C. Pour concrete collar:
   1. Bottom of Collar: Top of existing collar or 6 inches below top of proposed collar, whichever is at a higher elevation.
   2. Top of Collar: Bottom of existing asphalt pavement.
   3. Apply tack coat to all exposed surfaces.
   4. Fill excavation with asphalt concrete and, while still hot, compact flush with adjacent surface.

3.12 INSTALLATION TOLERANCES

A. Asphalt Pavement:
   1. Course thickness and surface smoothness within the tolerances specified in Caltrans Standard Specification Sections 39-6.01, 39-6.02 and 39-6.03.
   2. Total Thickness: Not less than indicated.

B. Trench Patch:
   1. Compacted surface: Within 0.01 foot of adjacent pavement.
HMC Architects

2. Do not create ponding.

C. Adjust Covers:
   1. Compacted surface: Up to 0.01 foot higher, and no lower, than adjacent pavement.
   2. Do not create ponding.

END OF SECTION
SECTION 32 12 43
POROUS FLEXIBLE PAVING

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Porous pavement system.

1.02 RELATED SECTIONS

A. Lawns and Grasses - Section 32 92 00
B. Planting - Section 32 93 00
C. Irrigation - Section 32 84 00

1.04 SYSTEM DESCRIPTION

A. The Grasspave2 porous pavement system provides vehicular and pedestrian load support for grass areas, while protecting grass roots from harmful effects of traffic.

B. Major Components of the Complete System
1. Grasspave2 units, assembled in rolls.
2. Engineered sand and gravel base course.
3. Hydrogrow soil amendment and fertilizer, supplied with Grasspave2.
4. Sand fill or USGA greens mix.
5. Selected grass from seed, hydroseeding/hydro-mulching, or sod.
6. Selected topsoil (only for seeded installation).
7. Mulch (needed only for seeded or hydroseeded installations).

C. The Grasspave2 grass paving units, sand, and base course work together to support imposed loading.

D. The Grasspave2 grass paving units, Hydrogrow, and sand fill contribute to vegetation support.
1.05 SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Shop Drawings: Submit design detail showing proper cross-section.

C. Samples: Submit manufacturer’s sample of Grasspave2 10” x 10” section of Grasspave2 material.

D. Installation Instructions: Manufacturer’s printed installation instructions. Include methods for maintaining installed products.

E. Certificates:
   1. Manufacturer signed certificate stating the product is made in the USA.
   2. Submit Material Certificates for base course and sand (or USGA mix) fill materials
   3. Product certificates signed by the manufacturer certifying material compliance of polyethylene used to make Grasspave2 units.
   4. ISO Certificate certifying manufacturer’s quality management system is currently registered to ISO 9001:2008 quality standards.

F. LEED Submittals: Provide documentation of how the requirements of Credit will be met:
   1. List of proposed materials with recycled content. Indicate post-consumer recycled content and pre-consumer recycled content for each product having recycled content.
   2. Product data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content.
   3. Description of Grasspave2 in stormwater design to limit the disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.
   4. Designing elements for Grasspave2 to limit the disruption and pollution of natural water flows by managing stormwater runoff.
   5. Documenting the use of Grasspave2 to reduce heat islands to minimize the impact on microclimates and human and wildlife habitats.

G. Substitutions: No material will be considered as an equivalent to the Grasspave2 unit specified herein unless it meets all areas of this specification without exception. Manufacturers seeking to supply what they represent as equivalent material must submit records, data, independent test results, samples, certifications, and documentation deemed necessary by the Specifier to prove equivalency.

H. Manufacturer’s Material Certification: Product manufacturers shall provide certification of compliance with all applicable testing procedures and related specifications upon written request. Request for certification shall be submitted by the purchasing agency no later than the date of order placement.

I. Product manufacturers shall also have a minimum of 30 years’ experience producing products for porous pavement systems.
J. Manufacturer Quality Certification: ISO Certification certifying manufacturer’s quality management system for its Grasspave2 system is currently registered to ISO 9001:2008 quality standards. Any alternate materials submitted shall provide a certification that their porous pavement system manufacturing process is part of an ISO program and a certification will be required specifically stating that their testing facility is certified and in accordance with ISO.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer’s unopened packaging until ready for installation.

B. Protect Grasspave2 units/rolls from damage during delivery and store rolls upright, under tarp, to protect from sunlight, when time for delivery to installation exceeds one week.

C. Store Hydrogrow in a dark and dry location

D. Handling: Protect materials during handling and installation to prevent damage

1.07 MAINTENANCE SERVICE

A. Installer responsible for maintenance of grass plants – water/irrigation, fertilizing, mowing – for one growing season. DO NOT AERATE. See Grasspave2 Maintenance Guide from Invisible Structures

B. System to be maintained by Maintenance and Operations after one growing season.

1.08 Project Conditions

A. Maintain environmental conditions within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

B. Do not begin installation of porous pavements until all hard surface paving adjacent to porous pavement areas, including concrete walks and asphalt paving, is completed.

C. Install turf when ambient air temperatures is at least 55 degrees F (13 degrees C).

D. In cold weather, do not use frozen materials or materials mixed or coated with ice or frost, and do not build on frozen base or wet, saturated or muddy subgrade.

E. Protect partially completed paving against damage from other construction traffic when work is in progress.

F. Adequately water sod or grass seed to assure germination of seed and growth of root system.

G. Grass coverage on the sand-filled Grasspave2 rings must be completed within one week: See Part 3 Execution.
H. DO NOT DRIVE, PARK ON, or use Grasspave2 system for two or three mowing cycles until grass root system has matured (about 3 to 4 weeks for sod or 6 to 8 weeks for seeded areas). Any barricades constructed must still be accessible by emergency and fire equipment during and after installation.

1.09 LIMITED WARRANTY

A. Invisible Structures, Inc. (ISI) warrants to its purchasers that all products furnished by ISI will be free from defects in material and/or workmanship.

B. This warranty shall be extended for a period of five (5) years following the date of shipment by ISI.

C. Providing a written claim is presented to ISI within the warranty period and after inspection by ISI showing the materials have failed under this warranty, all defective materials shall be refurnished under this warranty, at no charge, excluding re-installation costs. This in lieu of all other warranties expressed or implied and is the sole warranty extended by ISI.

D. Our liability under this warranty is limited to the refurnishing of materials and does not include any responsibility for incidental, consequential, or other damages of any nature.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturer: Invisible Structures, Inc., which is located at: 1600 Jackson St. Suite 310; Golden, CO 80401; Toll Free Tel: 800-233-1510; Tel: 303-233-8383; Email: request info (sales@invisiblestructures.com); Web: www.invisiblestructures.com.

B. Substitutions: Submit for approval by District.

2.02 GRASSPAVE2

A. Composition:
   1. Manufactured in the USA.
   2. High density polyethylene (HDPE): 100 percent recycled materials.
   3. Color: black
   6. Hydrogrow soil amendment and fertilizer, provided by manufacturer with Grasspave2.

B. Performance Properties:
   1. Maximum Loading Capability: 15,940 psi (2.29 million psf, 109,906 kPa) when filled with sand.
   3. Wheelchair Access testing for ADA Compliance: Passing Rotational Penetrometer testing.
5. System Permeability (Grasspave2, sand, base course): 2.63 to 38.55 inches of water per hour.
6. Effective Imperviousness (E.I.): 10%.

C. Dimensions (individual units are assembled and distributed into rolls):
   1. Roll area: From 108 sq ft (10 sq m) to 538 sq ft (50 sq m), in 108 sq ft (10 sq m) increments
   2. Roll Widths: From 3.3 ft (1 m) to 8.2 ft (2.5 m), in 1.6 ft (0.5 m) increments.
   3. Roll Lengths: From 32.8 ft (10 m) to 65.6 ft (20 m), in 3.3 ft (1 m) increments.
   4. Roll Weights: From 41 lbs (19 kg) to 205 lbs (93 kg), in 41 lbs (19 kg) increments.
   5. Unit Nominal Width by Length: 20 inches by 20 inches (0.5 m by 0.5 m) or 40 inches by 40 inches (1 m by 1 m).
   6. Nominal Depth: 1 inch (2.5 cm) – for rolls and individual units.
   7. Unit Weight: 18 oz (510 g) or 5 lbs. (2.27 kg).
   8. Volume Solid: 8 percent.

2.03 SYSTEM MATERIALS

A. Base Course: Sandy gravel material from local sources commonly used for road base construction (recycled materials such as crushed concrete or crushed asphalt are NOT acceptable).
   1. Conforming to the following sieve analysis and requirements:
      a. 100 percent passing sieve size 1 inch (25 mm).
      b. 90-100 percent passing sieve size 3/4 inch (19 mm).
      c. 70-80 percent passing sieve size 3/8 inch (9 mm).
      d. 55-70 percent passing sieve size #4.
      e. 45-55 percent passing sieve size #10.
      f. 25-35 percent passing sieve size #40.
      g. 3-8 percent passing sieve size #200.
   2. Provide a base course material nearly neutral in pH (range from 6.5 to 7.2) to provide adequate root zone development for turf.
   3. Material may be either "pit run" or "crusher run." Avoid using clay based crusher run/pit run. Crusher run material will generally require coarse, well-draining sand conforming to AASHTO M6 or ASTM C 33 to be added to mixture (20 to 30 percent by volume) to ensure long-term porosity.
   4. Alternative materials such as crushed shell, limerock, or crushed lava may be used for base course use, provided they are mixed with sharp sand (20 to 30 percent) to ensure long-term porosity, and are brought to proper compaction. Without added sand, crushed shell and limerock set up like concrete and become impervious.
   5. Alternative size and/or composition of base course materials should be submitted to Invisible Structures, Inc. (Manufacturer) for approval.

B. Sand Fill for Rings and Spaces Between Rings: Clean sharp sand (washed concrete sand). Choose one of the following:
   1. Coarse, well-draining sand, such as washed concrete sand conforming to AASHTO M6 or ASTM C-33.
   2. United States Golf Association (USGA) greens, section - sand mix “The Root Zone Mixture.”
C. Turf Conditioner:
   1. Hydrogrow, a proprietary soil amendment manufactured by Invisible Structures, Inc. and provided with Grasspave2.
   2. NO SUBSTITUTIONS.

D. Grass
   1. Sod: Use 13 mm (0.5") thick (soil thickness) rolled sod from a reputable local grower. Species should be wear resistant, free from disease, and in excellent condition. Sod shall be grown in sand or sandy loam soils only. Sod grown in soils of clay, silt, or high organic materials such as peat, will not be accepted.

PART 3 - EXECUTION

3.01 Inspection
   A. Examine subgrade and base course installed conditions. Do not start porous paving installation until unsatisfactory conditions are corrected. Check for improperly compacted trenches, debris, and improper gradients.
   B. For fire lane installations: prior to installing base course for turf paving, obtain approval of local fire authorities of sub-base.
   C. Start of installation constitutes acceptance of existing conditions and responsibility for satisfactory performance. If existing conditions are found unsatisfactory, contact District for resolution.

3.02 PREPARATION

A. Subgrade Preparation:
   1. Prepare subgrade as specified in Section 32 11 32. Verify subgrade in accordance with porous paving system manufacturer's instructions.
   2. Proper subgrade preparation will enable the Grasspave2 rolls/units to connect properly and remain level and stationary after installation.
   3. Excavate area allowing for unit thickness, the engineered base depth (where required), and 0.5 inch (1.25 cm) for depth of sod root zone or topsoil germination area (when applicable).
   4. Provide adequate drainage from excavated area if area has potential to collect water, when working with in-place soils that have poor permeability.
   5. Ensure in-place soil is relatively dry and free from standing water.
   6. Uniformly grade base.
   7. Level and clear base of large objects, such as rocks and pieces of wood.

B. Base Preparation:
   1. Install Base as specified in Section 32 10 00. Verify engineered base (if required) is installed in accordance with porous paving system manufacturer’s instructions.
   2. Coordinate base installation and preparation with subdrains specified in Section 32 11 32.
   3. If required, place a geotextile separation layer between the natural ground and the 'engineered base'.
   4. If required, install the specified sub-drain and outlet according to construction drawings.
5. Coordinate base installation and preparation with irrigation and drip irrigation lines specified in Section 32 84 00.
6. Place engineered base in lifts not to exceed 6 inches (150 mm), compacting each lift separately to 95 percent Modified Proctor.
7. Leave 1 inch (2.5 cm) of depth below final grade for porous paver unit and sand fill and 0.5 inch (1.25 cm) for depth of sod root zone or topsoil germination area (when applicable).

3.03 ON-SITE MANUFACTURER’S FIELD REPRESENTATIVE
A. A qualified Manufacturer’s field representative shall be available for a pre-construction meeting via phone or in person and will provide installation videos, design details, installation instructions, and the technical specifications.
B. The time for on-site observation shall be indicated in the Contract Documents and included in the base bid price.

3.04 HYDROGROW INSTALLATION
A. Spread all Hydrogrow mix provided (spreader rate = 4.53 kg per 100 m2 (10 lbs per 1076 ft2) evenly over the surface of the base course with a hand-held, or wheeled, rotary spreader.
B. The Hydrogrow mix should be placed immediately before installing the Grasspave2.

3.05 GRASSPAVE2 INSTALLATION
A. Install the Grasspave2 units by placing units with rings facing up, and using snap-fit connectors, pegs and holes, provided to maintain proper spacing and interlock the units. Units can be easily shaped with pruning shears or knife. Units placed on curves, slopes, and high traffic areas shall be anchored to the base course, using 40d common nails with fender washer, as required to secure units in place. Tops of rings shall be between 6 mm to 13 mm (0.25" to 0.5") below the surface of adjacent hard-surface pavements.
B. Install sand in rings as they are laid in sections by "back-dumping" directly from a dump truck, or from buckets mounted on tractors, which then exit the site by driving over rings already filled with sand. The sand is then spread laterally from the pile using flat bottomed shovels and/or wide "asphalt rakes" to fill the rings. A stiff bristled broom should be used for final "finishing" of the sand. The sand must be "compacted" by using water from hose, irrigation heads, or rainfall, with the finish grade no less than the top of rings and no more than 6 mm (0.25") above top of rings.

3.06 Installation of Grass
A. Grass coverage on the sand-filled rings must be completed within one week. Sand must be re-installed and leveled and Grasspave2 checked for integrity if rings become exposed due to wind, rain, traffic, or other factors.
1. Install thin sod directly over sand filled rings, filled no higher than the top of the rings. Sod strips should be placed with very tight joints. Sodded areas must be fertilized and kept moist during root establishment (minimum of 3 weeks). DO NOT DRIVE ON SYSTEM: Sodded areas must be protected from any traffic, other than emergency vehicles, for a period of 3 to 4 weeks, or until the root system has penetrated and established well below the Grasspave2 units.

B. Adequately water sod or grass seed to assure germination of seed and growth of root system.

3.07 Protection

A. Sodded areas must be protected from any traffic, other than emergency vehicles, for a period of 3 to 4 weeks, or until the root system has penetrated below the Grasspave2 units.

3.08 FIELD QUALITY CONTROL

A. Remove and replace segments of Grasspave2 units where three or more adjacent rings are broken or damaged, reinstalling as specified, so no evidence of replacement is apparent.

B. Perform cleaning during the installation of work and upon completion of the work. Remove all excess materials, debris, and equipment from site. Repair any damage to adjacent materials and surfaces resulting from installation of this work.

3.09 MAINTENANCE

A. Maintain grass in accordance with manufacturer’s instructions and as specified in Section 32 92 00 Manufacturers of Turfs and Grasses.

B. Lawn Care: Normal turf care procedures should be followed, including de-thatching.

C. DO NOT AERATE. Aerator will damage the Grasspave2 units. Aeration is not necessary in a sand root zone.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, tools and equipment necessary to install synthetic grass surfacing system as indicated on the plans and as specified herein; including components and accessories required for a complete installation, including but not limited to:
   1. Acceptance of prepared sub-base.
   2. Coordination with related trades to ensure a complete, integrated, and timely installation: aggregate base course, sub-base material (tested for permeability), grading and compacting, piping and drain components (when required); as provided under its respective trade section.

B. Related Work:
   1. Sustainable Design Requirements (LEED) - Section 01 81 13
   2. Excavation and Fill – Section 31 23 00
   3. Aggregate Base Course – Section 32 11 32

1.02 REFERENCE STANDARDS

   5. D5034 - Standard Test Method of Breaking Strength and Elongation of Textile Fabrics (Grab Test).

1.03 PERFORMANCE REQUIREMENTS

A. Completed synthetic grass surfacing system shall be capable of meeting the following performance requirements:
   1. ASTM D4491: Water permeability test. Synthetic grass surface shall drain at a rate of 250 inches or more, of water per hour.
   2. ASTM D1338: Tuft bind. Synthetic grass surfacing shall have a tuft bind, without infill material of 9 pounds or more.
1.04 SUBMITTALS

A. Substitutions: Other products are acceptable if in compliance with all requirements of these specifications. Submit alternate products for approval prior to bidding in accordance with Section 01 33 00 - Submittal Procedures.
1. Provide substantiation that proposed system does not violate any other manufacturer's patents, patents allowed or patents pending.
2. Provide a sample copy of insured, non-prorated warranty and insurance policy information.

B. Comply with Section 01 33 00 - Submittal Procedures. Submit for approval prior to fabrication.

C. Product Data:
1. Submit manufacturer's catalog cuts, material safety data sheets (MSDS), brochures, specifications; preparation and installation instructions and recommendations.
2. Submit fiber manufacturer's name, type of fiber and composition of fiber.
3. Submit data in sufficient detail to indicate compliance with the contract documents.
4. Submit manufacturer's instructions for installation.

D. Samples: Submit samples, illustrating details of finished product in amounts as required by General Requirements, or as requested.

E. List of existing installations: Submit list including respective District's representative and telephone number.

F. Warranties: Submit warranty and ensure that forms have been completed in District's name and registered with approved manufacturer.

1.02 QUALITY ASSURANCE

A. Comply with Section 01400, Quality Control Requirements.

B. Manufacturer Qualifications: Engaged in manufacturing synthetic grass surfacing products for a minimum of fifteen (15) years.
1. Manufacturer shall be experienced in the manufacturing and installation of specified type of synthetic grass surfacing system. This includes use of a ridged monofilament fiber, texturized monofilament fiber, backing, the backing coating, and the installation method.
2. Manufacturer shall own and operate its own manufacturing plant. Manufacturing the fiber, tufting of the fibers into the backing materials and coating of the synthetic grass system must be done in-house by manufacturer.
3. Manufacturer must hold ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.

C. Installer/Contractor Qualifications: Company shall specialize in performing the work of this section.
1. Company shall provide competent workmen skilled in this specified type of synthetic grass system installation.

2. The designated Supervisory Personnel on the project shall be certified, in writing by the manufacturer, as competent in the installation of specified type of synthetic grass system, including gluing seams and proper installation of the infill material.

3. Company shall be certified by the manufacturer and licensed (if required).

D. Pre-Installation Conference: Conduct conference at project site at time to be determined by Landscape Architect. Review methods and procedures related to installation including, but not limited to, the following:
   1. Inspect and discuss existing conditions and preparatory work performed under other contracts.
   2. In addition to Contractor and Installer, arrange for the attendance of installers affected by the work, District’s representative, and Landscape Architect.

E. The Installer/Contractor shall verify special conditions required for the installation of the synthetic grass system if required.

F. The Installer/Contractor shall notify Landscape Architect of any discrepancies.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store components with labels intact and legible.

B. Store materials/components in a secure manner, under cover and elevated above grade.

C. Protect from damage during storage, handling and installation. Protect from damage by other trades.

D. Inspect all delivered materials and products to ensure they are undamaged and in good condition.

1.03 SEQUENCING AND SCHEDULING

A. Coordinate the Work with installation of work of related trades as the Work proceeds.

B. Sequence the Work in order to prevent deterioration of installed system.

1.04 WARRANTY

A. See Section 01 33 00 - Submittal Procedures, for Additional Warranty Requirements.

B. The Installer/Contractor shall provide a warranty to the District that covers defects in materials and workmanship of the synthetic grass product for a period of eight (8) years from the date of completion. The synthetic grass manufacturer must verify that their representative has inspected the installation and that the work conforms to the manufacturer’s requirements. The manufacturer’s warranty shall include general wear and damage caused from UV degradation. The warranty shall specifically exclude vandalism, and acts of God beyond the control of the District or the manufacturer. The
warranty shall be fully third party insured; pre-paid for the entire 8 year term and be non-prorated. The Installer/Contractor shall provide a warranty to the District that covers defects in the installation workmanship, and further warrant that the installation was done in accordance with both the manufacturer's recommendations and any written directives of the manufacturer's representative. The insurance policy must be underwritten by an “AM Best” A rated carrier and must reflect the following values:
1. Pre-Paid 8-year insured warranty.
2. Maximum per claim coverage amount of $32,000,000.
3. Minimum of thirty-two million dollar $32,000,000 annual aggregate.
4. Must cover full 100% replacement value of total square footage installed.
5. Policies that include self-insurance or self-retention clauses shall not be considered.
6. Policy cannot include any form of deductible amount.
7. Sample policy must be provided at time of bid to prove that policy is in force. A letter from an agent or a sample Certificate of Insurance will not be acceptable.

PART 2 - PRODUCTS

2.01 MANUFACTURER AND DISTRIBUTOR

A. Manufacturer: FieldTurf USA, Inc. 175 N. Industrial Blvd, Calhoun, GA 30701
B. Distributor: Heavenly Greens – 370 Umbarger Rd. San Jose, CA, 408-723-4954
C. Substitutions: Submit for approval by District.

2.02 MATERIALS AND PRODUCTS

A. Product: NXM Lush Nutmeg.
B. Synthetic grass surfacing system shall consist of the following:
1. Synthetic grass surfacing made with a combination of ridged monofilament polyethylene fibers and texturized monofilament fibers, tufted into a fibrous, non-perforated, porous backing.
2. Infill: Graded dust-free silica sand that partially covers the synthetic grass. Graded dust-free acrylic coated silica sand or volcanic ash may be substituted for silica sand as requested by Architect.
3. Glue, thread, seaming fabric and other materials used to install and mark the synthetic grass.
C. Synthetic grass surfacing system shall have the following properties:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM D1577</td>
<td>Fiber Denier</td>
<td>10800</td>
</tr>
<tr>
<td>ASTM D1577</td>
<td>Secondary Fiber Denier</td>
<td>5600</td>
</tr>
<tr>
<td>ASTM D5823</td>
<td>Pile Height</td>
<td>1.625”</td>
</tr>
<tr>
<td>ASTM D5793</td>
<td>Stitch Gauge</td>
<td>3/8”</td>
</tr>
<tr>
<td>ASTM D5848</td>
<td>Pile Weight</td>
<td>65 oz/square yard</td>
</tr>
<tr>
<td>ASTM D5848</td>
<td>Primary Backing</td>
<td>7oz/square yard</td>
</tr>
<tr>
<td>ASTM D5848</td>
<td>Secondary Backing</td>
<td>20 oz/square yard</td>
</tr>
<tr>
<td>ASTM D5848</td>
<td>Total Weight</td>
<td>92 oz/square yard</td>
</tr>
<tr>
<td>Standard</td>
<td>Property</td>
<td>Value</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>ASTM D1338</td>
<td>Tuft Bind (Without Infill)</td>
<td>9 lbs</td>
</tr>
<tr>
<td>ASTM D4491</td>
<td>Turf Permeability</td>
<td>250 inches/hour</td>
</tr>
<tr>
<td>N/A</td>
<td>Infill Component</td>
<td>2.75 lbs/square foot</td>
</tr>
</tbody>
</table>

**D.** Synthetic grass surfacing product shall consist of soft spined monofilament fibers and texturized monofilament fibers tufted into a primary backing with a secondary backing.

**E.** Backing:
1. Primary backing shall be a double-layered polypropylene fabric treated with UV inhibitors.
2. Secondary backing shall consist of an application of porous urethane to permanently lock the fiber tufts in place.
3. Perforated (with punched holes), backed turf is unacceptable.
4. Turf with attached scrim in lieu of porous urethane is unacceptable.

**F.** Primary fiber shall be 10,800 denier, low friction, and UV-resistant fiber measuring not less than 1.625 inches high. Secondary fiber shall be 5,600 denier.

**G.** Infill materials shall be approved by the manufacturer.
1. Infill shall consist of graded dust-free sand. Graded dust-free acrylic coated silica sand or volcanic ash may be substituted for silica sand as requested by Architect.

**H.** Glue and seaming fabric, for seaming of synthetic grass shall be as recommended by the synthetic grass manufacturer.

**2.03 QUALITY CONTROL IN MANUFACTURING**

**A.** The manufacturer shall own and operate its own manufacturing plant in North America. Both tufting of the fibers into the backing materials and coating of the turf system must be done in-house by the synthetic grass manufacturer. Outsourcing of either is unacceptable.

**B.** The manufacturer shall have full-time certified in-house inspectors at their manufacturing plant that are experts with industry standards.

**C.** The manufacturer’s full-time in-house certified inspectors shall perform pre-tufting fiber testing on tensile strength, elongation, tenacity, and denier, upon receipt of fiber spools from fiber manufacturer.

**D.** Primary backing shall be inspected by the manufacturer’s full-time certified in-house inspectors before tufting begins.

**E.** The manufacturer’s full-time in-house certified inspectors shall verify “pick count”, yarn density in relation to the backing, to ensure the accurate amount of face yarn per square inch.

**F.** The manufacturer’s full-time, in-house, certified inspectors shall perform product inspections at all levels of production including during the tufting process and at the final stages before the synthetic grass is loaded onto the truck for delivery.
G. The manufacturer shall have its own, in-house laboratory where samples of synthetic grass are retained and analyzed, based on standard industry tests, performed by full-time, in-house, certified inspectors.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that all sub-base leveling is complete prior to installation.

B. Installer/Contractor shall examine the surface to receive the synthetic grass and accept the sub-base planarity in writing prior to the beginning of installation.
   2. Acceptance is dependent upon the District’s test results indicating compaction and planarity are in compliance with manufacturer’s specifications.
   3. The surface shall be accepted by Installer as “clean” as installation commences and shall be maintained in that condition throughout the process.

C. Compaction of the aggregate base shall be 90%, in accordance with ASTM D1557 (Modified Proctor procedure); and the surface tolerance shall not exceed 0-1/4 inch over 10 feet and 0-1/2 inch from design grade.

D. Correct conditions detrimental to timely and proper completion of Work.

E. Do not proceed until unsatisfactory conditions are corrected.

F. Beginning of installation means acceptance of existing conditions.

3.02 PREPARATION

A. Prior to the beginning of installation, inspect the sub-base for tolerance to grade.

B. Sub-base acceptance shall be subject to receipt of test results (by others) for compaction and planarity that sub-base is in compliance with manufacturer’s specifications and recommendations.

C. When requested by Architect, installed sub-base shall be tested for porosity prior to the installation of the synthetic grass system. A sub base that drains poorly is an unacceptable substrate.

3.03 INSTALLATION

A. The installation shall be performed in full compliance with approved Shop Drawings.

B. Only trained technicians, skilled in the installation of synthetic grass systems working under the direct supervision of the approved installer supervisors, shall undertake any cutting, sewing, gluing, shearing, top-dressing or brushing operations.

C. The designated Supervisory personnel on the project must be certified, in writing by the manufacturer, as competent in the installation of this material, including gluing seams and proper installation of the Infill material.
D. Install at location(s) indicated, to comply with final shop drawings, manufacturers'/installer's instructions.

E. The Installer/Contractor shall strictly adhere to specified procedures. Any variance from these requirements shall be provided in writing, by the manufacturer's on-site representative, and submitted to the Architect and/or District, verifying that the changes do not in any way affect the Warranty. Infill materials shall be approved by the manufacturer and installed in accordance with the manufacturer's standard procedures.

F. Synthetic grass system shall be installed directly over the properly prepared aggregate base. Extreme care shall be taken to avoid disturbing the aggregate base, both in regard to compaction and planarity.
   1. Repair and properly compact any disturbed areas of the aggregate base as recommended by manufacturer.
   2. Seams shall be flat, tight, and permanent with no separation or fraying.

G. Infill Materials:
   1. Infill materials shall be applied in thin lifts. The turf shall be brushed as the material is applied. The infill material shall be installed to a depth determined by the manufacturer.
   2. Infill material shall be installed in a systematic order.
   3. Infill materials shall be installed to fill the voids between the fibers and allow the fibers to remain vertical and non-directional. The Infill installation consists of graded dust-free silica sand. Graded dust-free acrylic coated silica sand or volcanic ash may be substituted for silica sand as requested by Architect.
   4. Infill density shall consist of 2.75 pounds of graded silica sand per square foot. The Installer/Contractor shall keep area clean throughout the project and clear of debris. Upon completion of installation, the finished project shall be inspected by the installation crew and an installation supervisor.

3.04 PROTECTION

A. Protect completed synthetic grass surfacing system throughout construction process until project completed.

3.05 RECYCLING

A. Manufacturer must commit in writing to offer a “take back” program that once the useful life of the turf surface has lapsed it can be removed and recycled.

END OF SECTION
SECTION 32 31 19

FENCES AND GATES - ORNAMENTAL METAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes
1. Ornamental Metal Fencing
2. Manually operated, swing and horizontal sliding gates
3. Rough and finish hardware, fasteners, and related accessories

B. Related Sections
1. Section 01 35 43, Special Environmental Requirements

1.02 REFERENCE STANDARDS

A. Conform to current adopted reference standards by date of issue of the current code cycle and the date of the Contract Documents.

B. American Society for Testing and Materials (ASTM)
1. ASTM A36 – Carbon Structural Steel
2. ASTM A123 - Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products
3. ASTM A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
4. ASTM A513 - Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing
5. ASTM A641 - Standard Specifications for Zinc-Coated (Galvanized) Carbon Steel Wire
6. ASTM A653 – Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
7. ASTM A568/A568M - General Requirements for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled.
8. ASTM B117 - Test Method of Salt Spray (Fog) Testing
10. ASTM C1107 - Packaged Dry, Hydraulic - Cement Grout (Non-Shrink)
11. ASTM D2247 - Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
13. ASTM D3359 - Test Method for Measuring Adhesion by Tape Test
14. ASTM F1184 - Industrial and Commercial Horizontal Slide Gates

C. American Welding Society (AWS)
1. AWS D1.1 - Structural Welding Code, Steel
2. AWS A5.1 - Carbon Steel Electrodes for Shielded Metal Arc Welding
3. AWS 5.5 - Low Alloy Steel Covered Arc Welding Electrodes.

D. American Institute of Steel Construction (AISC)
1. AISC Specifications - Manual of Steel Construction

E. 2016 California Building Code (CBC)
   1. CBC 10 - Chapter 10, Egress Requirements
   2. CBC 11 - Chapter 11, Accessibility
   3. CBC 19A - Chapter 19A, Concrete

1.03 SUBMITTALS

A. Product Data for each fencing system component and accessory item.

B. Shop Drawings, showing materials, construction and fabrication details, layout and erection diagrams as required, finish of materials and methods of anchorage to adjacent construction. Indicate welding by AWS code symbols.

C. Samples
   1. Color Selection Samples for each specified pre-finished item
   2. Record Samples of selected finishes
   3. Material Samples. If requested, submit samples of materials. Samples of finials, caps, and accessories shall be whole pieces.

D. Special Environmental Requirements. Submit documentation regarding recycled content and local/regional materials for all steel fence and gate components. Use the Special Environmental Product Documentation Submittal Form appended to Section 01 35 43.

1.04 DELIVERY, STORAGE AND HANDLING

A. Stack, store, and handle fencing sections and components to prevent damage during transit and storage at the site. Follow manufacturer’s instructions.

1.05 PROJECT CONDITIONS

A. Verify Existing Conditions. Verify conditions, affecting work of this Section, by taking accurate measurements at site of dimensions, elevations, and grades. Fabricate work to fit measured dimensions.

1.06 SPECIAL WARRANTY

A. Manufacturer and installer shall jointly warrant that the installed fencing and gates are and will remain free from defects in material and workmanship including cracking, peeling, blistering and corroding of finish for a period of at least 5 years from the date of Substantial Completion. Upon written notice from Owner, they shall promptly, without cost, and with the least practicable inconvenience to Owner correct such defects.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers
1. Ameristar Fencing Products, Tulsa, OK. Product: Aegis II
3. Builders Fence Company, Sun Valley, CA
4. Century Tube, Port of Pine Bluff, AR
5. Or equal, approved in accordance with Division 01, General Requirements, for substitutions.

2.02 MATERIALS

A. Steel Material: ASTM A924, A123 and ASTM A653, hot-dipped galvanized, G-90 for sheet steel, cold-rolled, butt welded, square or rectangular, minimum 45,000 psi.
   1. Model: Aegis II
      a. Fence Pickets: 1” x 14 GA square tubing, 4 inch centers.
      b. Fence rails, top and bottom: formed steel 1-3/4” x 14 GA square channels
      c. Fence posts: 2-1/2” x 12 GA square, 8 feet on center nominal, 6 feet high.
      d. Gate frame and pickets: same material as fence materials.

B. Screws: stainless steel, self-drilling hex-head screws. Type 304 or 316 stainless-steel fasteners.


D. Accessories: Internal retaining rod, panel brackets, post and picket caps, rubber grommets picket to rail.

E. Touch Up Material for Galvanized Coatings: Anodic zinc-rich coating or hot applied repair compound.

F. Concrete for Footings: as specified in Division 32 or as indicated on Drawings.

G. Non-Shrink Grout: ASTM C1107, premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 5,000 pounds per square inch in 24 hours and 8,000 pounds per square inch in 7 days; of consistency suitable for application and 30 minute working time.

2.03 COMPONENTS

A. Fencing: Ameristar, Aegis II Industrial Weight, or equal
   1. Style: Genesis G3, 3-rail, extended picket design with caps.
   2. Height: as indicated on drawings

B. EXIT Gates: galvanized square tube, ASTM A500, Grade B, at lintels and gate posts, minimum galvanizing coating of 1.8 ounces per sq. ft. 2-1/2 inches square. Final finish to match fencing finish.

C. Pedestrian Egress Gates - Style: Ameristar Exodus Double Swing
   1. Height: As indicated on Drawings.
   2. Color: Black
2.04 ACCESSORIES

A. Swing Gate Hardware. Provide hardware and accessories for each hinged, swing
gate, galvanized and shop finished to match adjacent gate and fence components.

1. Hinges: weldable steel barrel type hinge, ball bearing, non-removable steel pin.
Provide two hinges for each leaf up to 6 foot nominal height, and one additional
hinge for each additional 24 inches in height, or fraction thereof. 5" barrel hinge,
Model: 44-2003 King Architectural Metals, Los Angeles, CA, or equal. Two
hinges per leaf for gates up to 5'-11" wide, three hinges per leaf for 6' to 10' wide
gates.

   a. Latch: Fork type latch capable of retaining gate in closed position, except
gates with exit devices (panic hardware); Master-Halco, Series 16000 or
approved equal.

2. Locks: Self-latching bolt and deadbolt, 3/4 inch diameter, adjustable, lockable,
with lever handle, by Ameristar Lock or equal, keyed lock. Hardware shall not
require pinching, grasping or twisting motion. The lever of lever-activated
latches or locks for an accessible gate shall be curved with a return to within 1/2"
of the (face of) gate to prevent catching on the clothing or persons.

3. Double Gates: Provide center lockable cane bolt assembly mounted to gate
vertical frame designed to engage strike with anchors, set in concrete. At double
gates provide locking slide bolt. Cane Bolts not permitted at Path-of-Travel
gates.

4. Gate Hardware: Shall be mounted at 40" above finish floor.

5. All gates intended for pedestrian use, including ticket gates shall comply with all
applicable requirements of doors. All gates in the Path of Travel and as
indicated on the drawings shall require Exit Devices (panic hardware) as
specified above, CBC Sections 11B-309.4 and 11B-404.2.9. Signage is not
permitted in lieu of accessible or panic hardware.

6. Exit Device at Pedestrian Gates only, outswing in accordance with CBC Sections
1008.1.9, 1008.1.10, and 1008.2. Mounted 36" to 44" above finish floor. Exit
Device (panic hardware) shall be mounted to provide 36" clear minimum below
the device. Unlatching force not exceed 15# applied in direction of travel.

   a. Panic Bar, Pull, and Closer: Rim Type, Von Duprin 99 Series exit device
   pre-installed with Hex Key dogging option "HD", with Rockwood VRT16 Pull
   Handle and LCN 4040XPSRI Parallel Arm Closer or equal, compliant with
   CBC.

7. Accessories: 4" x 3" x 1/4" x 8" high galv. steel angle welded to strike-side frame
and 1" x 3" x 1/4" thick bolt keeper.

8. Fabricate galv. Steel lock box 16 ga x 3" high x 8" wide x 1-3/4" thick to encase
lockset, weld all joints and grind smooth, touch up with galvanizing compound.

9. Perforated Metal Panel: Manufactured by McNichols Co. Tampa, FL. Aluminum
Plate: Perforated , 0.125 inch thick with 1/4 inch diameter holes 42 percent open
area , 24 in. high by width of gate behind panic device centered at 40 in. above
finish surface. Secure to gate frame with #8 stainless steel screws at 6 in on
center.

10. Install 0.125 inch thick aluminum kick plate 10 inches high on push side (For
larger gates install at both sides). Clear space below gate shall be 3 inches
maximum from walking surface on both sides of the gate. Secure with #8
stainless steel screws 4 places each kick plate minimum.
B. Padlock: 5 pin cylinder, corrosion resistant, hardened steel shackles, 5/16 inch shackle diameter, No. 1158A54 by McMaster-Carr, Los Angeles, CA, or equal as approved in accordance with Division 01 for substitutions, master keyed to building standard one per gate.

C. Ground Rolling Gates: Ameristar PassPort II, steel assembly, 45,000 psi, 2 ball bearing 6" track wheels, two 3-inch rubber guide rollers. Full length inverted galvanized steel angle (track) 2-1/2" x 2-1/2" x 1/4" thick with welded anchors, set in concrete curb at level of finish surface to allow 6 inch diameter V-grooved wheels. Provided necessary attachment hardware.
   1. Gate opening: 4 bays (6 bays for 26' – 28' or 28' – 35') and as indicated on drawings.
   2. Posts: 4” square, 11 gauge.
   3. Toprails, uprights, diagonals rails: 2” square steel
   4. Bottom rails: 2” x 4” steel
   5. Pickets: face welded to frame, 1” square x 14 GA, air space 4’.
   6. Color: to match fencing color.
   7. Height: 6’ feet, unless noted otherwise.
   8. Caps: 2-1/2” standard flat caps.
   9. Include all accessories.

2.05 FABRICATION

A. Provide new stock of standard sizes specified or detailed. Fabricate materials in shop to produce high-grade metal work. Form and fabricate to meet required conditions.

B. Pickets, rails and posts shall be pre-cut to specified lengths. Rails pre-punched to accept rails.

C. Include bolts, screws and other fastenings necessary to secure work.

D. Conform applicable work to latest edition of AISC Specifications and AWS D1.1.

E. Accurately make and tightly fit joints and intersections in true planes with adequate fastenings.

F. Coordinate Work with work of other sections. Provide punchings and drillings indicated or required for attachment of Work to other Sections.

G. Welding: weld joints, unless otherwise indicated or specified, using shielded electric arc method. Use coated welding rods, not fluxed or type recommended by manufacturer for use with parent metal.

H. Grinding: Grind welds to smooth flush joints.

I. EXIT Gates: Fabricate posts and lintels to height indicated on drawing but no less than 6'-8", and ready to receive closer and gate hardware.
2.06 FINISHES

A. Galvanized finish for steel products, ASTM A123 and sheet steel ASTM A653.
   1. Clean surfaces of rust, scale, grease and foreign matter prior to finishing. Prepare in accordance with SSPC SP-2.
   2. Galvanize steel items to zinc coating thickness in accordance with ASTM A123, minimum Coating Grade 80 (1.9 oz/sq. ft.) and ASTM A653 for sheet steel G60 (0.60 oz/ft square). Surfaces shall be free of icicles, spangles and puddling. Provide venting holes at all enclosed sections, "V" notch, and drilled holes are acceptable. Locate to prevent rainwater from entering enclosed sections at exterior galvanized items. Galvanize after fabrication.

B. Base Coat: epoxy electrostatic powder coat over prepared galvanized steel, minimum thickness 2 mils.

C. Finish Coat: TGIC Polyester electrostatic powder coat topcoat. Thickness 2 mils, minimum.

D. Color: black.

PART 3 - EXECUTION

3.01 INSPECTION

A. Verify existing conditions are ready the work of this Section. Do not begin erection of fencing until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Post spacing: Line posts shall be spaced in line maximum of 96 inches on center.

B. Post Footings: Set posts in concrete footings 12 inches in diameter and 36 inches deep, unless noted otherwise on Drawings. Tops of footings: Crowned to shed water. Concrete mix: Minimum 3000 pounds per square inch.

C. Post Tops: Line posts shall be fitted with pressed steel caps. Gate post top: Welded flush and ground smooth.

D. Weld mount galvanized steel plate to accept lock box nearest latch with access to gate from outside of fence enclosure for Fire Department. Prime and paint plate to match fence color per Section 09 90 00.

3.03 GATES

A. Gate posts shall be set in accordance with the spacings shown in the drawings.
B. The gate shall be set upright with the V-grooved wheels positioned over the pre-installed steel V-track that transverses the gate opening. Roller guided shall be affixed to the gate posts at a height ever with the gate toprail to hold the gate in vertical position. Gate stops shall be welded to the end of the gate or track so gate cannot pass rollers in either direction.

C. Fabricate gates to size and configuration indicated on Drawings, complete with gate hardware.

D. Install locking fittings to accommodate owner’s keying system.

E. Attachments to gate shall be permanently secured to assembly. No clamp-on or exposed bolted fittings shall be permitted.

F. All gates intended for pedestrian use, shall comply with all applicable requirements of doors. All gates in the Path of Travel and part of the accessible route and as indicated on the drawings shall require Exit Devices (panic hardware) and meet all the requirements of an accessibly door in compliance with CBC Section 11B-404 and as specified above. Signage is not permitted in lieu of accessible or panic hardware.

END OF SECTION
SECTION 32 31 19.30
DECORATIVE ORNAMENTAL PRE-HUNG GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
A. Section Includes:

B. Related Sections:
   1. Division 03 Concrete
   2. Division 31 Earthwork

1.3 REFERENCES
A. American Society for Testing Materials:
   1. A239 Practice for Locating the Thinnest Spot in a Zinc (Galvanized) Coating on Iron or Steel Articles
   2. A653/A653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
   3. A1008/A1008M Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
   5. B117 Practice for Operating Salt Spray (Fog) Apparatus
   6. D523 Test Method for Specular Gloss
   7. D714 Test Method for Evaluating Degree of Blistering of Paints
   8. D1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
   9. D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
   11. D3359 Test Methods for Measuring Adhesion by Tape Test

1.4 SUBMITTALS
A. Product Data: Manufactures information for each type of product indicated.
B. Shop Drawings: Product elevations, sections, and details as necessary.

1.5 QUALITY ASSURANCE
A. The contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and the materials and techniques specified.
B. Provide complete fence system and gates, with all components provided by a single manufacturer, including all panels, posts, gates, fittings, and hardware.
C. Manufacturer Qualifications: Company specializing in manufacturing of steel ornamental picket fence systems with a minimum of 5 years documented experience.

1.6 PRODUCT HANDLING AND STORAGE
A. Panels, gates, posts, and accessories to be delivered to the project site assembled and coated. Upon receipt at the job site, all materials shall be checked to ensure that no damages occurred during shipping.
B. Materials shall be handled and stored properly to protect against damage, weather, vandalism, and theft.

PART 2 – PRODUCTS

2.1 GUARDSMAN® COMMERCIAL DECORATIVE ORNAMENTAL SWING GATES
A. Approved manufacture: Merchants Metals or equal.
B. Products from other qualified manufacturers: Shall have ten years or more experience manufacturing steel ornamental picket fencing will be considered by the architect as equal if approved in writing 10 days prior to biddings, and they meet all specifications for design, size, gauge of metal parts, and fabrication. Picket fences and gates must be obtained from a single source.
C. Gate frame: Galvanized steel tubular members manufactured per ASTM F2408, with a minimum yield strength of 45,000 psi; with minimum 2” square 14 gauge per ASTM F900.
D. Clear opening: as indicated on drawings.
E. Chain Link:
   (A) Chain Link:
      1. Fabric 2” mesh 9 gauge: GBW,
   C. Posts: Galvanized square steel tubular members manufactured per ASTM F2408, having minimum yield strength of 45,000 psi; with minimum post size per ASTM F900.
      1. Gate Panel up to 8’-6” Height:
         a. Gate Panel Width up to 5’- 0” post shall be 3” square; 12 gauge.
F. Hardware:
   1. Pressed steel hinges shall be securely attached to post to prevent slippage and allow gate leaf to swing 180°.
All primary components shall receive a thorough cleaning and pre-treatment with a 10-step process: Hot alkaline cleaner, clear water rinse, hot iron phosphate application, clear water rinse, reverse Osmosis rinse, dry off oven heat, zinc enriched powder primer coat at 2-4 mils., gel oven heat, Ultra polyester finish T.G.I.C. powder coat at 2-4 mils., and final curing oven.
1. Color for all components – Choose color: Black, Green, Gray, or Custom.

2.2 ACCESSORIES

A. Industrial drive rivets hold pickets to rails and rails are securely welded to gate frame. Rivets must have a sheer strength of 1,500 lbs. and a holding power of 1,100 lbs.
B. Options:
   1. Electric lock supplied and installed by Merchants Metals. May be used with key pad, card reader, Intercom, and CCTV all supplied by others. Not for use with panic bar.
   2. Lock box supplied by Merchants Metals to accept mortise lock. Mortise locks supplied by other. Not for use with Panic Bar.
   3. Panic Bar Exiting Device (Stainless Steel Latch Mechanism DAC-DETEx V40) (Weather Resistant). (STANDARD)
   4. Hydraulic gate closer Sentinel / Dorma 7305 (STANDARD)

C. Post Caps: Cast malleable iron or formed steel welded to uprights.
   1. Choose Cap style: Ball or flat tops – on all uprights.

2.2 GATES

A. Ornamental swing gate (see section 32 31 19.20)
B. Ornamental picket cantilever slide gates (see section 32 31 19.40)

2.4 SETTING MATERIALS

A. Concrete: Minimum 28 day compressive strength of 3,000 psi.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify areas to receive gate are completed to final grades and elevations.
B. Property lines and legal boundaries of work to be clearly established by the general contractor or property owner.

3.2 GATE INSTALLATION
A. Install Pre-hung Gate manufactured with a welded brace below grade to help prevent shipping damages.

B. Attach all hardware to gate in such a way that it cannot be removed by unauthorized persons.

C. Set posts in concrete. Dig holes having a diameter 4 times the diameter of the post, and 6” deeper than the bottom of the post. Crown concrete at top to shed water.

3.3 CLEANING

A. Clean up debris and remove from the site.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. The CONTRACTOR shall provide all labor, materials, supplies, tools, and transportation and perform all operations in connection with and reasonably incidental to complete the installation of the automatic sprinkler irrigation systems as shown on the drawings. Items hereinafter are included as an aid to take off, and are not necessarily a complete list of work items.
1. Trenching, stockpiling, excavation, materials, and refilling trenches.
2. Furnishing materials and installation for complete system including piping, valves, fittings, sprinkler heads, automatic controls, and final adjustment of heads to insure complete coverage.
3. Line voltage connections to the irrigation controllers and low voltage control wiring from controllers to remote control valves.
4. Replacement of unsatisfactory materials.
5. Clean-up, inspection and approval.
6. All work of every description mentioned in the specification and/or addenda thereto, all other labor, and materials reasonably incidental to the satisfactory completion of the work, including clean-up of the site, as directed by the Project Representative.
7. Tests.
8. As-built record drawings.

B. Work Specified Elsewhere:
1. Irrigation water stub-out.
2. 120 volt A.C. electrical stub-out to controller location.
3. Irrigation sleeves.
4. Electrical conduit in structure for 24-volt wire.
5. Metering communication lines and conduit.

C. Related Work
1. Existing Plants to Remain – Section 32 12 00
2. Finish Grading – Section 31 22 19
3. Soil Preparation – Section 32 91 13
4. Lawns and Grasses – Section 32 92 00
5. Planting – Section 32 93 00
6. Landscape Maintenance – Section 32 93 25

1.02 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Irrigation System:
1. Measurement: Irrigation system installation is measured on a lump sum basis.
2. Payment: The contract lump sum price paid for the Irrigation System shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing the Irrigation System, complete in place.

1.03 SUBMITTALS

A. Product Data: Submit manufacturer catalog information on all material to be used on the project as specified on the legend, notes, details and plans. Redline or highlight exact items on page to be submitted. Complete material list shall be submitted prior to performing any work.

B. Substitutions: No substitution will be permitted without prior written approval by the Project Representative. If the product is approved and, in the opinion of the Project Representative, the substituted product does not perform as well as the specified product, the Contractor shall replace it with the specified product at no additional cost to the Project Representative.

C. All equipment or materials installed or furnished without prior approval of the Project Representative may be rejected and the Contractor may be required to remove the equipment or material at their own expense.

1.04 CLOSEOUT SUBMITTALS

A. Project As-built Record Documents: The Contractor shall maintain in good order in the field office, one complete set of black line prints of all sprinkler drawings which form a part of the contract, showing all water lines, electrical, sprinklers, valves, stub-outs. In the event any work is not installed as indicated on the drawings, such work shall be corrected and dimensioned accurately from the building walls. All underground stub-outs for future connections and valves shall be located and dimensioned accurately from building walls on all as-built record drawings. In addition to the hard copies a full sized scanned PDF will be required at completion.

B. Controller Chart:
1. Provide one laminated controller chart showing the area covered by controller for each automatic controller supplied at the maximum size controller door will allow. Chart shall be a reduced drawing of the actual "as-built" system. If controller sequence is not legible when the drawing is reduced to door size, the drawing shall be enlarged to a size that is readable and placed folded, in a sealed plastic container, inside the controller door.
2. Controller chart shall be a blackline print with a different color used to show area of coverage for each station. Charts must be completed and approved by the Project Representative prior to final inspection of the irrigation system.

C. Maintenance and Operating Instructions and Manuals:
1. Contractor shall prepare an Operation and Maintenance Manual, organized in a 3-ring binder, containing the following information.
Contractor's name, address, and telephone number. Duration of guarantee, periods as specified herein, list of equipment with names and addresses of local manufacturer's representatives with duration of written warranties. Complete operating and maintenance instructions on all equipment spare parts lists and related manufacturer's information.

2. Submit the Operation and Maintenance Manual to the Project Representative within 10 Calendar Days of completion of work of this Section and as a condition of project acceptance.

D. Irrigation Audit, Irrigation Survey, and Irrigation Water Use Analysis:
   1. All landscape irrigation audits shall be conducted by a local agency landscape irrigation auditor or a third-party certified landscape irrigation auditor. Landscape audits shall not be conducted by the person who design the landscape or installed landscape.
   2. In large projects or projects with multiple landscape installations (i.e. production home developments) an audit rate of 1 to 7 lots or approximately 15% will satisfy this requirement.
   3. For new construction and rehabilitated landscape projects installed after December 1, 2015, as described in Section 490.1:
      a. the project applicant shall submit an irrigation audit report with the Certificate of Completion to the local agency that may include, but is not limited to: inspection, system tune-up, system test with distribution uniformity, reporting overspray or run off that causes overland flow, and preparation of an irrigation schedule, including configuring irrigation controllers with application rate, soil types, plant factor, slop, exposure and any other factors necessary for accurate programming.

1.05 QUALITY ASSURANCE & GENERAL REQUIREMENTS

A. Qualifications: The Contractor, personally or through an authorized and competent representative, shall supervise the work constantly, and shall as far as possible keep the same foreman and workmen on the job from commencement to completion. The workmanship of the entire job must in every way be first class, and only experienced and competent workmen will be allowed on the job. A minimum of five years’ experience of installing irrigation systems of similar scope, size and complexity as the system being installed under this scope of work is required for all on-site job superintendents.

B. Manufacturer's installation instructions and best practices: Manufacturer's installation instructions shall be followed in all cases when not shown in the Drawings or Specifications.

C. O.S.H.A. Compliance: All articles and services covered by this specification shall meet or exceed the safety standards established under the Federal Occupational Safety and Health Act of 1970, together with all amendments in effect as of the date of this specification.
D. All irrigation systems shall be installed to meet or exceed the requirements set forth in the California Department of Water Resources Model Water Efficient Landscape Ordinance.

E. Codes and Standards: Comply with all applicable codes and standards.
   1. All work and materials shall be in full accordance with the latest rules and regulations of the National Electric Code; published by the Western Plumbing Officials Association; California Code of Regulations, Title 23, Division 2. Department of Water Resources, Chapter 2.7. Model Water Efficient Landscape Ordinance; and other State or local laws regulations. Nothing in these drawings or specifications is to be construed as to permit work not conforming to these codes.
   2. When the specifications call for materials or construction of a better quality or larger size than required by the above mentioned rules and regulations, the provision of the specifications shall take precedence over the requirements of said rules and regulations.
   3. Contractor shall furnish, without extra charge, any additional material and labor when required by the compliance with these rules and regulations, though the work be not mentioned in these particular specifications or shown on the drawings.
   4. The Contractor shall erect and maintain barricades, guards, warning signs, and lights as necessary or required by O.S.H.A. regulations for the protection of the public or workmen.
   5. Any existing buildings, equipment, piping, pipe covering sewers, etc., damaged by the Contractor during the course of his work shall be replaced or repaired by the Contractor in a manner satisfactory to the Project Representative and at Contractor's own expense, before final payment is made. The Contractor shall be responsible for damage caused by leaks in the piping systems being installed or having been installed under this contract. He/she shall repair, at his/her own expense, all damage so caused, in a manner satisfactory to the Project Representative.
   6. The Contractor shall pay for all permits, licenses, and fees required.

1.06 EXISTING CONDITIONS

A. Protection of Existing Structures and Utilities
   1. The Drawings show, if applicable, existing above and below grade structures and utilities that are known to the Project Representative. Locate known existing installations before proceeding with construction operations that may cause damage to such installations. Existing installations shall be kept in service where possible and damage to them shall be repaired with no adjustment of Contract Sum. Verify with Project Representative if As Built drawings are available.
   2. If other structures or utilities are encountered, request Project Representative to provide direction on how to proceed with the Work. If a structure or utility is damaged, take appropriate action to ensure the safety of persons and property.

B. Trench Interference with Existing Tree Root Systems: Prior to trenching, layout main and lateral line locations within drip Line of trees and review locations with
HMC Architects

Project Representative. Relocate any lines that may interfere with existing root systems to avoid or reduce damage to root systems as accepted by Project Representative.

C. Provide barricades, coverings, warning signs, lights and other protection required by local code or OSHA to prevent damage to existing improvements to remain and to protect the public.

1.07 LAYOUT OF WORK

A. The Contractor shall stake out the irrigation system as shown on the drawings. These areas shall be checked by the Contractor and Project Representative before construction is started. Any changes, deletions or additions shall be determined at this check.

B. Due to the scale of the Drawings, it is not possible to indicate all piping offsets, fittings, sleeves, etc., which may be required. Carefully investigate the conditions affected all of the work and plan accordingly, and furnish all required fittings. Install system in such a manner to avoid conflicts with planting, utilities and architectural features.

C. Do not instal l the irrigation system as shown on the Drawings when it is obvious in the field that obstructions, grade differences or discrepancies in arc dimensions exist that might not have been considered. Bring such obstruction or differences to the attention of the Project Representative. Notify and coordinate irrigation Work with applicable contractors for location and installation of piping and sleeves through or under walls, pavement and structures. In the event this notification is not given, the Contractor shall assume full responsibility for any revision necessary.

1.08 SEQUENCING AND SCHEDULING

A. Acceptance: Do not install main line trenching prior to acceptance by Project Representative of rough grades completed under another Section.

B. Coordination: Coordinate with the all other trades the sleeving, power requirements of the project, prior to the start of construction.

1.09 INSTRUCTION

A. After the system has been installed and approved, the Contractor shall instruct the Project Representative and or Maintenance Contractor, in complete operation and maintenance of the irrigation system.

PART 2 - MATERIALS

2.01 PIPE AND FITTINGS

A. All main line pipe shall be manufactured from purple-colored PVC material and shall be printed on two sides with the wording "CAUTION-RECLAIMED WATER".
B. Main lines (constant pressure); 2” and smaller shall be PVC 1120-Schedule 40 plastic pipe. Pipe shall be made from NSF approved Type 1, Grade 1 PVC compound conforming to ASTM D1785.
   1. Solvent weld main lines: At changes in direction or branch mains, use appropriate Schedule 40 PVC solvent weld fittings as approved by the Uniform Plumbing Code.

C. Lateral lines (non-pressure): 3/4” and larger shall be 1120-Schedule 40 PVC plastic pipe. All lateral lines shall be connected with Schedule 40, Type I, Grade I, PVC solvent weld fittings.

D. Connections between main lines and RCV’s shall be of Schedule 80 PVC (threaded both ends) nipples and fittings.

E. Risers shall be as follows:
   Schedule 80 PVC threaded nipples and Schedule 80 PVC ells as shown in the construction details. Offset risers shall be Cobra connector Model CC-600 (1/2”x6”).

2.02 GATE VALVES

A. Gate valves 2” and smaller shall meet the following requirements:
   1. Valves shall be of stainless steel (304 or higher) construction with non-rising stem, cross handle and threaded connections. Valves shall be Leemco Model #LGT-SS or approved equal. Size as shown on the drawings.
   2. Install in 10” diameter plastic valve box as detailed.

2.03 QUICK COUPLING VALVES

A. Quick coupling valves shall be as shown on the drawings. Use purple covers for use with recycled water. Install in 10” diameter plastic valve box as detailed.

2.04 CONTROLLERS

A. Controller’s size and model shall be as listed on the drawings.

B. Final location(s) of controller shall be approved by the Project Representative.

C. Controller requires 120v power. Maximum power output of controller is 2.5 amps.

D. Install Controller and accessories as detailed and per Manufacturer’s details.

2.05 CONTROL WIRE

A. Control wire shall be copper with U.L. approval for direct burial in ground, size #14-Common ground wire shall have white insulating jacket; control wire shall have insulating jacket of color other than white or yellow. Runs over 2,000 lineal feet shall be #12- AWG-UF 600 volt copper wire. Splices shall be made with 3M-DBY seal packs.
HMC Architects

B. Provide a separate ground wire for each controller.

C. Provide a minimum of two spare control wires into each RCV box for future. Spare wires shall be yellow in color.

2.06 ELECTRIC REMOTE CONTROL VALVES

A. Electric remote control valves sizes shall be shown on drawings.

B. Electric remote control valve shall be a normally closed 24 VAC solenoid actuated globe pattern valve.

C. Valves shall be made of durable glass-filled nylon with a pressure rating of 200 PSI

D. Valve shall have external and internal bleed for manual operation.

E. Provide and install one Schedule 80 PVC FIPT threaded true union ball valve with EPDM O-rings on the upstream side of valve and one Schedule 80 union on the downstream side of valve. Ball valve shall be Spears True Union model 2300. Match valve size when sizing ball valve and union.

F. All electric remote control valves for dripline or drip systems shall include a wye filter with a 200 mesh stainless steel screen and pressure regulator on the valve or downstream of the valve.

2.07 IDENTIFICATION TAG

A. Identification tags for all electric control valves shall be manufactured by Christy. Tag numbers shall match stationing in controller and as shown on as-built drawings. Provide one yellow station number tag for each electric control valve and an additional purple one for recycled water system as follows:
   1. Recycled water systems: Christy ID.STD.Y1 and Christy ID.MAX.P2.RC006.

B. Identification tags for all quick coupling valves are ONLY required for recycled water systems. Tags shall be Christy model ID.MAX.P2.RC006.

2.08 VALVES BOXES

A. ELECTRIC REMOTE CONTROL VALVE BOXES:
   1. All electric remote control valve boxes that service non-drip systems shall be installed within a NDS Pro Series Model 214BC, 213BCBLK (14”x19”) or 221BCB, 222BCB BLK (13” x 24”) plastic valve box with bolt down plastic lid or approved equal. Size of box is dependent on the size of valve. Lid shall be marked: "Irrigation Control Valve."

   2. All electric remote control valve boxes that service dripline or drip systems shall be installed within a NDS Pro Series Model 221 BCB (13” x 24”) plastic valve box with bolt down plastic lid or approved equal. Lid shall be marked: "Irrigation Control Valve."
3. Use purple colored boxes with bolt down lid marked “RECLAIMED OR RECYCLED WATER” and with bilingual non-potable warning and symbol for all recycled water systems. NDS Pro Series Model 213PBCR (14” x 19”)OR 217PBCR (13” x 20”) plastic valve box with bolt down plastic lid or approved equal

4. Heat brand controller letter and numbers into lid. Minimum text height to be 2”.

B. GATE VALVE AND QUICK COUPLING VALVE BOXES:
1. All gate valve and quick coupling valve shall be installed within a NDS Pro Series Model 212BCB or 211BBCBLK plastic valve box with plastic lid or approved equal. Use 8” sleeve to encase gate valve.

2. Use purple color boxes with bolt down lid marked “RECLAIMED OR RECYCLED WATER” and with bilingual non-potable warning and symbol. NDS Pro Series Model 211PBCR plastic valve box with plastic lid or approved equal.

3. Heat brand the letters “GV” into lid. Minimum text height to be 2”.

C. DRIP COMPONENT BOXES:
1. All drip components shall be installed within a 6” round black plastic valve box with plastic lid. NDS Standard Series Model 107BC plastic valve box with plastic lid or approved.

2. Use purple color lid with non-hinged bolt down lid marked “RECLAIMED OR RECYCLED WATER” and with bilingual non-potable warning and symbol. NDS Standard Series Model 107PBCR plastic valve box with plastic lid or approved equal.

2.09 SPRINKLER HEADS AND BUBBLERS
A. All sprinkler heads shall be as listed on the drawings.

B. Pop-up spray sprinklers shall include a built in check valve in the body to hold up to 14 feet of head.

C. Pop-up spray sprinklers shall include built in pressure regulation in the body.

D. Use 30 psi regulators for all spray nozzles and 45 psi regulators for all rotating nozzles. Use 12” pop-ups in shrub and ground cover areas and 6” pop-ups in turf areas.

E. Riser units and nipples shall be the same size as the inlet to the sprinkler body.

F. Use purple caps on sprinkler head for recycled water systems.

2.10 DRIPLINE & DRIPLINE COMPONENTS
A. Dripline shall be as listed on the drawings.

B. Tubing shall be low density, UV resistant, polyethylene tubing with internal pressure-compensating, drip emitters impregnated into the tubing spaced at 12 or 18 inches.
C. The built in emitters shall be capable of delivering 0.6 gallons per hour per emitter.

D. All dripline systems shall have a manual flush valve at each isolated zone within the systems. Multiple flush valves may be required per drip zone.

E. All dripline systems shall have air relief valve(s) at the highest elevation point(s) within each isolated zone. Install one air relief valve for every 500 linear feet of dripline.

F. Use purple colored tubing for recycled water systems.

2.11 CHECK VALVE

A. Spring check valve shall be Schedule 40 PVC with ½ lb spring and stem rated at 150 PSI.

B. Check valves shall be NDS. Use KSC series swing check valve for all uphill flow direction valves and KC series spring check for all downhill flow direction valves. Size per line size of lateral line.

2.12 MISCELLANEOUS INSTALLATION MATERIALS

A. Solvent cement and primer for solvent weld joints shall be of make and type approved by manufacturer(s) of pipe and fittings. Cement shall be maintained at proper consistency throughout use.

B. Pipe joint compound shall be non-hardening, non-toxic materials designed specifically for use on threaded connections in water carrying pipe. Performance shall be same as RectorSeal #5.

2.13 SUB-METER

A. Sub-meter shall be as listed on drawings.

B. Sub-meter shall be line size and be hard-wired to the campus’ BMS per School standards.

PART 3 - INSTALLATION

3.01 PREPARATION

A. Schedule and coordinate placement of materials and equipment in a manner to effect the earliest completion of work in conformance with construction and progress schedule.

3.02 HANDLING AND STORAGE

A. Protect work and materials from damage during construction and storage as directed by the Project Representative.
B. Handle plastic pipe carefully; especially protect it from prolonged exposure to sunlight. Any section of pipe that has been damaged will be discarded and removed and replaced if installed.

3.03 LAYOUT

A. Lay out work as accurately as possible in accordance with diagrammatic drawings.

B. Where site conditions do not permit location of piping, valves and heads where shown, notify Project Representative immediately and determine relocation in joint conference.

C. Prior to installation, the Contractor shall stake out the routing of all pressurized main lines and sprinkler heads for approval by Project Representative.

D. Run pipelines and automatic control wiring in common trenches wherever practical.

3.04 EXCAVATING AND TRENCHING

A. Excavation shall be in all cases ample in size to permit the pipes to be laid at the elevations intended and to permit ample space for joining.

B. Make trenches for pipelines deep enough to provide minimum cover from finish grade as follows:
   - 18” - 24 “minimum cover over main lines to control valves and quick coupling valves.
   - 18” minimum cover over control wires from controller to valves.
   - 12” minimum cover over RCV controlled lateral lines to sprinkler heads.

C. Restore surfaces, existing underground installations, etc., damaged or cut as a result of excavations, to original conditions in a manner approved by the Project Representative.

D. Where other utilities interfere with irrigation trenching and pipe work, adjust the trench depth as instructed by the Project Representative.

3.05 ASSEMBLING PIPELINES

A. All pipe shall be assembled free from dirt and pipe scale. Field cut ends shall be reamed only to full pipe diameter with rough edges and burrs removed.

B. Install plastic pipe in accordance with manufacturer’s recommendations.

C. Install 3" wide detectable warning tape above all pressurized main lines as shown in the details. Use Christy model #TA-DT-2-BIRR for potable irrigation systems or #TA-DT-2-PIRR for recycled irrigation water systems

D. Solvent Weld Joint:
1. Prepare joint by first making sure the pipe end is square. Then, de-burring the pipe end, and clean pipe and fitting of dirt, dust and moisture.

2. Dry insert pipe into fitting to check for proper sizing. Pipe should enter fitting 1/3 to 2/3 depth of socket.

3. Coat the inside socket surface of the fitting and the male end of the pipe with P-70 primer (manufactured by Weld-On). Then without delay, apply Weld-On 711 cement liberally to the male end of the pipe and also apply 711 cement lightly to the inside of the socket. At this time, apply a second coat of cement to the pipe end.

4. Insert pipe immediately into fitting and turn 1/4 turn to distribute cement and remove air bubbles. The pipe must seat to the bottom of the socket and fitting. Check alignment of the fitting. Pipe and fitting shall be aligned properly without strain to either.

5. Hold joint still for approximately thirty (30) seconds and then wipe the excess cement from the pipe and fitting.

6. Cure joint a minimum of thirty (30) minutes before handling, at least six (6) hours before allowing water in the pipe.

E. Threaded Joint:

1. Field threading of plastic pipe or fittings is not permitted. Only factory formed threads will be permitted.

2. Factory made nipples shall be used wherever possible. Field cut threads in metallic pipe will be permitted only where absolutely necessary. When field threading, cut threads accurately on axis with sharp dies.

3. All threaded joints shall be made up with pipe joint compound. Apply compound to male threads only.

4. Where assembling metallic pipe to metallic fitting or valve, not more than three (3) full threads shall show when joint is made up.

5. Where assembling to threaded plastic fitting, take up joint no more than one full turn beyond hand tight.

6. Where assembling plastic pipe, use strap type friction wrench only; do not use metal-jawed wrench.

F. Cap or plug openings as pipeline is assembled to prevent entrance of dirt or obstructions. Remove caps or plugs only when necessary to continue assembly.

G. Where pipes or control wires pass through sleeves, provide removable non-decaying plug at ends of sleeve to prevent entrance of earth.

3.06 REMOTE CONTROL VALVES

A. Install where shown on drawings and group together where practical. Limit one remote control valve per box. No exceptions!

B. Locate valve boxes 12” from and perpendicular to walk edges, buildings and walls. Provide 12” between valve boxes where valves are grouped together.

C. Thoroughly flush main line before installing valves.

D. Install in shrub or groundcover areas where possible.
E. Label control line wire at each valve with an I.D. tag, indicating identification number of valve (controller and station number). Attach label to control wire.

F. Flow control stems shall be adjusted or tuned per manufacturer recommendations.

3.07 AUTOMATIC CONTROL WIRE

A. Run lines along mains wherever practical. Tie wires in bundles with pipe wrapping tape at 10' intervals and allow slack for contraction between strappings.

B. Loop a minimum of three (3) feet of extra wire in each valve box; both control wire and ground wire.

C. Connections shall be made by crimping bare wires with brass connectors and sealing with watertight resin sealer packs.

D. Splicing will be permitted only on runs exceeding 2500’. Locate all splices at valve locations within valve boxes.

E. Where control lines pass under paving, they shall pass through Schedule 40 electrical PVC conduit. Do not tape wire in bundles inside conduit.

3.08 AUTOMATIC CONTROLLER

A. Provide and install automatic irrigation controller in approximate locations shown on drawings. The exact location will be determined on the site by the Project Representative. Provide conduit and wire and connect to 120 volt switch accessible to controller for ease of maintenance.

B. Connect control lines to controller in sequential arrangement according to assigned identification number on valve. Each control line wire shall be labeled at controller with a permanent non-fading label indicating station number of valve controlled. Attach label to control wire. (CONVENTIONAL WIRE)

C. Provide each irrigation controller with its own independent low voltage common ground wire. (CONVENTIONAL WIRE)

D. Provide each controller with its own ground rod. Separate the ground rods by a minimum of eight feet. The ground rod shall be an eight foot long by 5/8" diameter U.L. approved copper clad rod or as recommended by controller manufacturer. Install no more than 6” of the ground rod above finish grade. Connect #8 gauge wire with a U.L. approved ground rod clamp to rod and back to ground screw at base of controller with appropriate connector. Make this wire as short as possible, avoiding any kinks or bending. Install a minimum of 8’ away from pedestal housing base unless otherwise noted.

3.09 BUBBLERS, SPRINKLER HEADS AND QUICK COUPLING VALVES

A. Thoroughly flush lines before installing heads, bubblers or QCV’s.
HMC Architects

B. Locate bubblers, heads and QCV’s as shown in the drawings and details.

C. Adjust sprinkler heads for proper distribution and trim.

D. Install lawn heads 1” above grade in seeded lawn area at time of installation. Lower to finished grade after turf is well established and as directed by Project Representative.

3.10 DRIPLINE AND DRIPLINE COMPONENTS

A. Thoroughly all flush lines driplines.

B. Install dripline a minimum of 12” away from all buildings and 6” off hardscapes for shrubs and groundcover. 2” of paving for all no-mow or sod type grasses.

C. Space driplines equally throughout the planting area as detailed. Refer to legend for emitter and row spacing of dripline. Adjust alternate rows so emitters are spaced in a triangular pattern.

D. All dripline tubing shall be buried 4” below finish grade and stapled down every 4’ and at each change in direction with a 6” tubing stake.

E. For slopes greater than 10:1, modify dripline row spacing on the bottom 1/3 of the slope to be 25% greater at the bottom of the slope.

F. Install flush valves at the low end of each drip zone minimum of 2 valves are required for each valve. Refer to manufacturer details for installation instructions.

G. Install air vacuum relief valve(s) at high point(s) of each planting area. Refer to drawings for approximate locations. Revise locations in field based on actual grades of the site. Locate 1 valve per every 500’ of dripline. Refer to manufacturer details for installation instructions.

H. Thoroughly saturate soil prior to planting. Provide additional surface watering as required to keep plant root systems moist during planting establishment period.

3.11 BACKFILLING

A. Backfill only after piping and wire has been inspected and approved.

B. Backfill material shall be the earth excavated from the trenches, free from rocks, concrete chunks, and other foreign or coarse materials.

C. Place backfill materials in 6” layers and compact by jetting or tamping to a minimum compaction of 90 percent of original soil density.

D. Dress off areas to finish grade and remove excess soil, rocks, or debris remaining after backfill is completed.
E. If settlement occurs along trenches, and adjustments in pipes, valves, and sprinkler heads, soil, sod, or paving are necessary to bring the system, soil, sod, or paving to the proper level or the permanent grade, the Contractor, as part of the work under this contract, shall make all adjustments without extra cost to the Project Representative.

3.12 FIELD QUALITY CONTROL

A. Coverage Tests:
1. Perform coverage tests in the presence of Project Representative, after sprinkler or drip system is completed. Test system to assure that all areas are irrigated completely and uniformly.
2. Do not spray onto pavement or structures. Adjust arc nozzles as needed to provide full coverage without over spray.

B. Adjusting and Cleaning:
1. System adjustment:
   b. Heads: Adjust for alignment and coverage.
   c. If it is determined that coverage could be improved by adding additional driplines or a nozzle change, make such changes as required to provide adequate coverage to all plant material.
   d. Perform final cleaning of all risers, dripline, heads, and equipment for proper operation. Demonstrate operation and uniform coverage in the presence of the Project Representative prior before final acceptance.

3.13 TESTING

A. Perform test as specified below. Remake any faulty joints with all new materials. Use of cement or caulking to seal leaks is absolutely prohibited.

B. Contractor shall:
1. Notify the Project Representative at least three (3) days in advance of testing.
2. Perform testing at his/hers own expense.
3. Center load piping with small amount of backfill to prevent arching or slipping under pressure. No fitting shall be covered.
4. Apply the following tests after welded plastic pipe joints have cured at least twenty-four (24) hours.
   a. Solvent Weld Mainline: Remove all the air from the piping system then test live (constant pressure) and QCV lines hydrostatically at 125 PSI minimum. Lines will be approved if test pressure is maintained for six (6) hours. The lines shall be restored to the original test pressure. The Contractor shall make tests and repairs as necessary until test conditions are met.
   b. Test RCV controlled lateral lines with water at line pressure and visually inspect for leaks. Retest after correcting defects.
3.14 GUARANTEE

A. It shall be the responsibility of the Contractor to fill and repair all depressions and replace all necessary lawn and planting due to the settlement of irrigation trenches for one year following completion and acceptance of the job.

B. The Contractor shall also guarantee all materials, equipment and workmanship furnished by him to be free of all defects of workmanship and materials, and shall agree to replace at his expense, at any time within one year after installation is accepted, any and all defective parts that may be found.

3.15 MAINTENANCE

A. Continuously maintain irrigation system in areas indicated in the Contract during the progress of work and for a period of 90 days after substantial completion.

B. It is Contractor's responsibility to turn over the irrigation in a first-class condition at the end of the maintenance period.

C. Maintenance Schedule: Contractor shall submit schedule of maintenance tasks to be performed for Project Representative review and approval. At a minimum, maintenance staff shall be on-site two times per month. It is not the intention of these Specifications to allow a "quick cleanup" at the end of the maintenance period, but rather that the work be continuous and ongoing.

D. Proper irrigation system maintenance includes the overall supervision of the system, controller scheduling, routine adjustments and necessary repairs.

E. Maintain irrigation system for optimum performance, as per manufacturer's specifications, by inspecting the entire system on an on-going basis. This includes cleaning and adjusting all bubbler heads, dripline and valves for proper coverage.

3.16 CLEAN-UP

A. When work of this section has been completed and at such other times as may be directed, remove all trash, debris, surplus materials, and equipment from site.

END OF SECTION
SECTION 32 91 13

SOIL PREPARATION

PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: Provide all soil and soil amendments products, including all imported topsoil as required to make up deficiencies in quantity of soil available on site, or as supplemental soil mixture to second-story planters. Execute all labor to achieve soil preparation, complete, as shown and as specified.

B. Related Work:
   1. Sustainable Design Requirements (LEED) - Section 01 81 13
   2. Existing Plants to Remain – Section 31 12 00
   3. Finish Grading - Section 31 22 19
   4. Porous Flexible Paving - Section 32 12 43
   5. Irrigation System - Section 32 84 00
   6. Lawns and Grasses - Section 32 92 00
   7. Planting - Section 32 93 00
   8. Landscape Maintenance - Section 32 93 25

1.02 DEFINITIONS

A. Existing Soil: Area of undisturbed soil where no rough grading is to be done. No topsoil is to be placed. Only surface cultivation and soil amending are included in this Section. See Existing Plants to Remain – Section 31 12 00.

B. Subgrade: Soil level resulting from the rough grading work under another Section. Cultivation of all subgrade areas prior to amending is included in this Section.

C. Topsoil: Soil stockpiled for spreading over prepared subgrade.
   1. Stockpiled Site Soil: Soil stripped from the site prior to rough grading work under another Section, to be spread and amended as work under this Section.
   2. Imported Topsoil: Off-site topsoil imported and stockpiled under this Section, to be spread and amended also as work under this Section.

D. Backfill Mix: Native or imported topsoil, amended per Soils Report direction.

1.03 SUBMITTALS

A. Product Data: Manufacturer's current catalog cuts and specifications of the following:
   1. Fertilizer
   2. Amendments, as recommended in soils test results
   3. Compost
   4. Herbicide
   5. Filter fabric
   6. Topsoil
B. Quality Control Submittals:
   1. Testing Agency: Waypoint Analytical California (formerly Soil and Plant Laboratory, Inc.), 1101 S. Winchester Blvd., Suite G-173, San Jose, CA 95128; or Perry Laboratory, 424 Airport Blvd., Watsonville, CA 95076, Tel. (831) 722-7606; or approved equal.
   2. Test Reports (in three (3) areas to be determined by District Representative):
      a. Stock-piled Native Topsoil:  Test for physical and chemical composition, horticultural suitability, phytophthora ramorum (Sudden Oak Death), herbicide contamination, soil texture, infiltration rate, pH, total soluble salts, sodium, and percent organic matter.
      b. Imported Topsoil:  Test for physical and chemical composition, horticultural suitability, phytophthora ramorum (Sudden Oak Death), herbicide contamination, soil texture, infiltration rate, pH, total soluble salts, sodium, and percent organic matter.
      c. Custom Soil Mix (e.g. lightweight mix, potting mix):  Test for physical and chemical composition and saturated weight per cubic foot.
      d. Nitrogen-treated Sawdust:  Test for physical and chemical properties.
      e. Compost:  Before delivery of the soil, the supplier shall submit a copy of lab analysis performed within the last three months by a laboratory that is enrolled in the US Composting Council's Compost Analysis Proficiency (CAP) program and using approved Test Methods for the Evaluation of Composting and Compost (TMECC).  The lab report shall verify:
         1) Feedstock Materials shall be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues.
         2) Organic Matter Content:  35% - 75% by dry weight.
         4) Maturity/Stability:  Shall have a dark brown color and a soil-like odor.  Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120°F) upon delivery or rewetting is not acceptable.  In addition, any one of the following is required to indicate stability:
            i. Oxygen Test < 1.3 O2 / unit TS / hr.
            ii. Specific Oxygen Test < 1.5 O2 / unit BVS
            iii. Respiration Test < 8°C / unit VS / day
            iv. Dewar Test < 20°C Temp. rise
            v. Solvita® > 5 Index value.
         5) Toxicity:  Any one of the following measures is sufficient to indicate non-toxicity:
            i. NH4- : NO3-N < 3
            ii. Ammonium < 500 ppm, dry basis
            iii. Seed Germination > 80% of control
            iv. Plant Trials > 80% of control
            v. Solvita® > 5 Index value
         6) Nutrient Content:  Provide analysis detailing nutrient content include N-P-K, Ca, Na, Mg, S, and B.
            i. Total Nitrogen content 0.9% or above preferred.
            ii. Boron:  Total shall be <80ppm; soluble shall be <2.5 ppm.
         7) Salinity:  Must be reported; < 6.0 mmhos/cm.
         8) pH shall be between 6.5 and 8; may vary with plant species.
   3. Certificates:  Certify strict compliance with accepted soil mixes and amendments, including rate of application.
1.04 PROJECT/SITE CONDITIONS

A. Existing Conditions: For protection of existing plants to remain, see Section 31 12 00 - Existing Plants to Remain.

B. Sequencing and Scheduling: Do not install imported topsoil, detention basin materials, or soil mix prior to acceptance of waterproofing and drainage in another section.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Stockpiled Site Topsoil:
1. Quantity: The approximate quantity of stockpiled site top-soil will not be known until demolition and rough grading have been completed.
2. Stockpiling: Stripped soil will be stockpiled on the site in a pre-approved location.
3. Composition: Fertile, friable, well-drained soil, of uniform quality, free of stones over 1/2-inch diameter, sticks, oils, chemicals, plaster, drain rock, base rock, concrete, and other deleterious materials.
4. Analysis:
   a. Site Soil -- Obtain a minimum of three (3) agricultural suitability analyses of the site soil at Contractor's cost.
   b. Imported Topsoil -- Obtain a minimum of one (1) agricultural suitability analyses of the proposed topsoil at Contractor's cost.
5. Test Results: Request Testing Agency to send one (1) copy of test results direct to the Landscape Architect and one (1) copy to the District's Representative. Site soil and imported topsoil shall be amended per soils analysis report.

B. Imported Topsoil:
1. Quantity: Import topsoil as soon as an insufficient quantity of site soil is verified. Quantity of topsoil to complete the work shall be calculated by the Contractor.
2. Stockpiling: Stockpile on site as directed by District's Representative.
3. Composition: To match or exceed in quality accepted site stockpiled soil, as determined by analysis similar to that described above.
4. Samples: The Landscape Architect reserves the right to take samples of the imported topsoil delivered to the site for conformance to the Specifications.
5. Rejected Topsoil: Immediately remove rejected soil off the site at Contractor's expense.

C. Compost: Compost shall be a well-decomposed, stable, weed-free organic matter course derived from waste materials including yard debris, wood wastes, or other organic materials not including manure or bio-solids meeting the standards developed by the US Composting Council (USCC). The product shall be certified through the USCC Seal of Testing Assurance (STA) Program (a compost testing and information disclosure program).

D. Backfill Soil Mix: Backfill: Native or imported topsoil, amended per Soils Report direction.
2.02 SOIL MIXES

A. Detention Basin Soil Mix:
   1. Refer to Civil Engineering sections.

B. Topsoil Mix:
   1. Mix will be based on soils analysis results.

C. Backfill Mix (for the top twelve (12) inches of backfill around the sides of the rootball of trees and shrubs):
   1. Mix will be based on soils analysis results and will include a minimum compost rate of four (4) cubic yards per 1,000 square feet of permeable area and shall be incorporated to a depth of six (6) inches into the soil. Soils with greater than 6% organic matter in the top six (6) inches of soil are exempt from adding compost and tilling.

2.03 ACCESSORIES

A. Fine Sand:
   1. Physical Properties (by dry weight basis):
      | Percent Passing | Sieve Size       |
      |                 |                 |
      | 100             | 4.76 mm (#4, 4 mesh) |
      | 95-100          | 1.00 mm (#18, 16 mesh) |
      | 65-100          | 500 micron (#35, 32 mesh) |
      | 0- 50           | 250 micron (#60, 60 mesh) |
      | 0- 20           | 105 micron (#140, 150 mesh) |
      | 0-  5           | 53 micron (#270, 270 mesh) |
   2. Chemical Properties: (by Saturation Extract Method):
      a. Soluble Salts/Salinity: Maximum conductivity of 3.0 millimhos/cm at 25 degrees C.
      b. Boron: Maximum concentration of 1.0 ppm.

B. Pre-emergence Weed Control:
   1. "Treflan 5G", by Elanco Products Co., (317) 261-3638, or (209) 486-3020 or "Enide 50W", by TUCO, (616) 385-6609.

C. Drain Rock:
   1. Description: Hard, durable, clean, screened, uniformly-sized broken stone or crushed gravel free of injurious materials or soil and all deleterious chemicals.
   2. Size: One (1) inch-diameter, gap-graded.

D. Water: Clean, fresh and potable, as available from District. Transport as required.

2.04 ORGANIC COMPONENTS - The following additives may or may not be used depending on the outcome of the soils report.

A. Coconut Coir:
   1. Type: Finely-shredded, light brown in color, suitable for horticultural purposes.

B. Nitrogen-Treated Sawdust:
   1. Type: Derived from redwood, fir or cedar wood sawdust.
2. Physical Properties:

<table>
<thead>
<tr>
<th>Percent Passing</th>
<th>Sieve Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>95-100</td>
<td>6.35 mm. (1/4 inch)</td>
</tr>
<tr>
<td>80-100</td>
<td>2.38 mm. (#8, 8 mesh)</td>
</tr>
<tr>
<td>0- 30</td>
<td>500 micron (#35, 32 mesh)</td>
</tr>
</tbody>
</table>

3. Chemical Properties:

- Nitrogen content (dry weight basis):
  - Wood of Redwood: 0.4 - 0.6%
  - Wood of Fir/Cedar: 0.56 - 0.84%
- Iron content (dry weight basis): 0.08% iron as metallic, minimum.
- Salinity/Soluble salts: Maximum 3.5 millimhos/cm at 25 degrees C. as determined by saturation extract method.
- Ash (dry weight basis): 0 - 6.0 percent maximum.

4. Treating Nitrogen Process: Thoroughly bulk-blend any of the following available sawdust types with the amendment specified:

- Urea Formaldehyde
- Sawdust: Per Cubic Yard
  - Hardwood: 4 pounds
  - Redwood: 2 pounds
  - Fir or Cedar: 4-1/2 pounds

C. Treated Fir/Pine Bark:

1. Physical Properties (dry weight basis):

<table>
<thead>
<tr>
<th>Percent Passing</th>
<th>Sieve Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>95-100</td>
<td>6.35 mm (1/4 inch)</td>
</tr>
<tr>
<td>80-100</td>
<td>2.38 mm (#8, 8 mesh)</td>
</tr>
<tr>
<td>0- 30</td>
<td>500 micron (#35, 32 mesh)</td>
</tr>
</tbody>
</table>

2. Organic Content (dry weight basis): 94 percent minimum as determined by ash analysis.

3. Chemical Properties:

- Nitrogen Content (dry weight basis): 0.8 percent minimum.
- Soluble Salts/Salinity: Maximum Saturation Extract Conductivity 3.0 millimhos/cm at 25 degrees C, by method.
- Iron (dry weight basis): 0.08 percent minimum.
- pH: 6.5 - 7.5

4. Wettability:
   a. When applied to a cup or small beaker of water @ 70 degrees F. in the amount of 1 teaspoon, the air-dry product shall become completely wet in a period not exceeding 2 minutes.
   b. All wetting agents to be non-phytotoxic at rate used.

2.05 COMMERCIAL FERTILIZERS

A. Pre-Plant Fertilizer:

1. Type: Slow-release fertilizer mixed by a commercial fertilizer supplier and consisting of the following percent by weight: 24-6-10, 18-6-12, or 15-9-12. Install per manufacturer’s recommended quantities.

2. Manufacturer: Osmocote by The Scotts Miracle-Gro Company, Tel. 1-800-270-3714.
2.06 CHEMICAL COMPONENTS - The following additives may or may not be used depending on the outcome of the soils report.

A. Ground Limestone: Agricultural limestone containing not less than 85% of total carbonates, ground to such fineness that 50% will pass #100 sieve and 90% will pass #20 sieve.

B. Dolomite Lime: Agricultural grade mineral soil conditioner containing 35% minimum magnesium carbonate and 49% minimum calcium carbonate, 100% passing #65 sieve. "Kaiser Dolomite 65 AG" by Kaiser, Inc. Mineral Products Department, or approved equal.

C. Gypsum: Agricultural grade product containing 80% minimum calcium sulfate.

D. Iron Sulfate (Ferric or Ferrous): Supplied by a commercial fertilizer supplier, containing 20% to 30% iron and 35% to 40% sulfur.

E. Sulfate of Potash: Agricultural grade containing 50% to 53% of water-soluble potash.

F. Single Superphosphate: Commercial product containing 20% to 25% available phosphoric acid.

G. Ammonium Sulfate: Commercial product containing approximately 21% ammonia.

H. Ammonium Nitrate: Commercial product containing approximately 34% ammonia.

I. Calcium Nitrate: Agricultural grade containing 15-1/2% nitrogen.

J. Urea Formaldehyde: Granular commercial product containing 38% nitrogen.


L. Soil Sulfur: Agricultural grade sulfur containing a minimum of 96% sulfur.


PART 3 - EXECUTION

3.01 SOIL MOISTURE CONTENT

A. General: Do not work soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in air or that clods will not break readily. Apply water, if necessary, to bring soil to an optimum moisture content for tilling and planting.

B. Range: Maintain within 2 percent above or below optimum moisture content at all times during the work.
3.02 CLEARING AND CULTIVATION

A. Clearing: Clear all planting areas of stones 1/2-inch diameter and larger, weeds, debris and other extraneous materials prior to soil preparation work.

B. Cultivation of Existing Soil:
   1. Cultivation: Rip or cultivate areas of existing soil to receive planting to a depth of 6 inches immediately prior to applying soil amendments.
   2. Tree(s) to Remain: Hand cultivate within the dripline of existing trees to remain. Depth of cultivation shall not exceed 2 inches. Cultivate immediately prior to amending existing soil.

C. Cultivation of Subgrade:
   1. Verification:
      a. Verify that subgrades for installation of topsoil have been established under rough grading. Do not spread topsoil prior to acceptance of subgrade work.
      b. Depth: Verify that subgrades are 12 inches minimum below finished grades, + 1 inch. Report all variations.
   2. Cultivation: Rip or cultivate subgrade in planting areas to a depth of 6 to 8 inches immediately prior to spreading topsoil.

3.03 SPREADING OF TOPSOIL

A. General: Spread topsoil over accepted subgrade prior to incorporating amendments.

B Restrictions: Do not commence spreading of topsoil prior to acceptance of soil cultivation above. Do not place topsoil under muddy (or frozen) conditions.

C. Topsoil Depth: Minimum depth of 12 inches after natural settlement and light rolling conforming to finished grades shown on Drawings.

3.04 SOIL AMENDMENT

A. Amending of Existing Soil:
   1. Preparation: Do not commence amending of existing soil prior to acceptance of soil cultivation above. Do not work soils under muddy conditions.
   2. Soil Amendments per 1,000 Square Feet: Incorporate thoroughly with top six (6) inches of all existing planting areas, components as identified in Soils Report for existing site soil. Compost shall be incorporated at a minimum of four (4) cubic yards per 1,000 square feet, unless soils report recommendations differ. Confirm with jurisdiction for WELO requirement.
   3. Intent: The above amendments and quantities are approximate and are for bidding purposes only. Following a site soil analysis by Testing Agency, composition of amendments may change.

B. Amending of Spread Topsoil:
   1. Soil Amendments per 1,000 square feet: Incorporate thoroughly with top twelve (12) inches, components as identified in soils report for existing site soil. Compost shall be incorporated at a minimum of four (4) cubic yards per 1,000 square feet, unless soils report recommendations differ.
3.05 PRE-EMERGENT

A. Apply pre-emergent weed control to all on-grade areas to receive woody and grass planting after incorporating soil amendments.

B. Apply strictly according to manufacturer's current printed specifications.

3.06 BLENDING OF AMENDMENT AND SOIL MIXES

A. Thoroughly bulk blend materials uniformly in stockpiles prior to installation on site, not in individual plant pits.

3.07 FIELD QUALITY CONTROL

A. Tests: Right is reserved to take samples of prepared soil for testing for conformity to specifications.

B. Rejected Materials: Remove off site at Contractor's cost. Pay cost of testing of materials, not meeting specifications.

END OF SECTION
PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: Provide work complete as shown and as specified.

B. Related Work:
   1. Sustainable Design Requirements (LEED) - Section 01 81 13
   2. Finish Grading - Section 31 22 19
   3. Porous Flexible Paving - Section 32 05 23
   4. Irrigation System - Section 32 84 00
   5. Soil Preparation - Section 32 91 13
   6. Planting - Section 32 93 00
   7. Landscape Maintenance - Section 32 93 25

1.02 REFERENCES


1.03 SUBMITTALS

A. Submit in accordance with Division 1, Section “Submittals”.

B. Product Data: Manufacturer's current catalog cuts and specifications for sod and seed.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Sod:
   1. Harvest and Delivery: Harvest from the source and deliver to project site within 24 hours. Deliver only as much sod as can be installed in one day's work.
   2. Review: Sod not transplanted within this time period shall be reviewed prior to installation.

1.05 PROJECT/SITE CONDITIONS

A. Existing Conditions: For protection of existing plants to remain, see Section 31 11 00 – Cleaning, Grubbing, and Stripping.

B. Climate Restrictions: Do not install grasses during rainy weather or when soil is saturated.

C. Soil Preparation: Do not install until soil preparation is complete and accepted by District’s Representative

D. Sub-grade and Drainage: Do not seed until acceptance of sub-grade and drainage.
E. Irrigation: Do not seed until irrigation is accepted and fully automated.

1.06 WARRANTY

A. Time Period: Warrant that seeded areas shall be in a healthy and flourishing condition of active growth six (6) months from date of Final Acceptance.

B. Appearance During Warranty: Seeded areas shall be free of dead or dying patches, and all areas shall show foliage of a normal density, size and color.

C. Delays: Delays caused by the Contractor in completing planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.

1.07 MAINTENANCE: See Section 32 93 25 - Landscape Maintenance.

PART 2 - PRODUCTS

2.01 BIOFILTRATION SOD

A. One year old nursery-grown sod, seeded of "Biofiltration Sod" as produced by Delta Bluegrass.

B. Sod shall be dense, healthy, field-grown on fumigated soil with the grass having been mowed at 1 in. height before lifting from field.

C. Sod shall be dark green in color, free of thatch, free from diseases, weeds and harmful insects.

D. Sod shall be reasonably free of objectionable grassy and broadleaf weeds. Sod shall be considered weed free if no more than ten (10) such weeds are found per 100 sq. ft. of sod.

E. Sod shall be rejected if found to contain the following weeds: (common bermudagrass), quackgrass, johnsongrass, poison ivy, nimbleweed, thistle, bindweed, bentgrass, perennial sorrel, bromeagrass.

F. All sod to be cut 1 1/2 in. deep.

2.02 POROUS FLEXIBLE PAVING SOD

A. One year old nursery-grown sod, seeded of "Bolero Plus" dwarf fescue - bluegrass mixture as produced by Delta Bluegrass.

B. Sod shall be dense, healthy, field-grown on fumigated soil with the grass having been mowed at 1 in. height before lifting from field.

C. Sod shall be dark green in color, free of thatch, free from diseases, weeds and harmful insects.
D. Sod shall be reasonably free of objectionable grassy and broadleaf weeds. Sod shall be considered weed free if no more than ten (10) such weeds are found per 100 sq. ft. of sod.

E. Sod shall be rejected if found to contain the following weeds: (common bermudagrass), quackgrass, johnsongrass, poison ivy, nimbleweed, thistle, bindweed, bentgrass, perennial sorrel, brome grass.

F. All sod to be cut 1 1/2 in. deep.

2.03 ACCESSORIES

A. Water: Potable water from College source. Transport and distribution by Contractor.

B. Pre-plant Fertilizer: See Soil Preparation - Section 32 91 13.

C. Top-Dress Fertilizer: 16-6-8 (N-P-K), see Planting - Section 32 93 00.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
   1. Grades: Verify that grades are within 1-inch plus of the required finished grades. Verify that fertilization has been installed.
   2. Stones, Weeds, Debris: Verify that all areas to receive grasses are clear of stones, crushed rock, and gravel larger than 1/2-inch diameter, weeds, debris and other extraneous materials.

3.02 PREPARATION

A. Excessive Soil Moisture: Do not commence work of this Section when soil moisture content is so great that excessive compaction will occur.

B. Inadequate Soil Moisture: Apply water, as necessary, to bring soil to an optimum moisture content for planting. Do not work soil when it is so dry that dust will form in air or that clods will not break readily.

3.03 LAWN INSTALLATION

A. Sod Bed Preparation:
   2. Moistening: After all unevenness in the soil surface has been corrected, lightly moisten the soil immediately prior to laying the sod.
   3. Timing: Sod immediately thereafter, provided the sod bed has remained in friable condition.

B. Sodding Operations:
   1. Starter Strip: Lay first row of sod in a straight line, with subsequent rows parallel to and tightly against each other. Stagger lateral joints. Do not stretch or overlap sod. Butt all joints tightly to eliminate all voids.
   2. Cutting: Use a sharp knife to cut sod to fit curves.
3. Tamping and Rolling: Thoroughly tamp and roll sod to make contact with sod bed. Roll each entire section of completed sod.
4. Watering: Thoroughly water sod immediately after installation to wet underside of the new sod pad and the soil immediately below to a depth of 6 inches.
5. Top-Dress Fertilizer: Apply at the rate of 6 to 8 pounds per 1,000 square feet at 25 days and at 50 days after sodding.

3.04 FIELD QUALITY CONTROL

A. Tests: Samples of materials may be taken and tested for conformity to Specifications at any time.

B. Rejected Materials: Remove rejected materials immediately from the District’s property at Contractor’s expense. Pay cost of testing of materials not meeting Specifications.

3.05 CLEANING

A. Erosion: Immediately restore eroded areas. Keep all adjacent paved surfaces cleaned of dirt, mud or stains and organic debris.

END OF SECTION
SECTION 32 93 00
PLANTING

PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: Provide planting complete, as shown and as specified.

B. Products Installed But Not Furnished Under This Section:
   1. Notification: Notify District at least two (2) weeks in advance of date when plants
      will be picked up and transported to the place of installation.
   2. Inspection: Inspect plants prior to acceptance and notify District of all
      unacceptable plants. Pick up of plants shall constitute acceptance for the
      purpose of warranties.

C. Related Work:
   1. Sustainable Design Requirements (LEED) - Section 01 81 13
   2. Existing Plants to Remain - Section 32 12 00
   3. Porous Flexible Paving - Section 32 12 43
   4. Finish Grading - Section 31 22 19
   5. Irrigation System - Section 32 84 00
   6. Soil Preparation - Section 32 91 13
   7. Lawns and Grasses - Section 32 92 00
   8. Landscape Maintenance - Section 32 93 25

1.02 REFERENCES

A. "An Annotated Checklist of Woody Ornamental Plants of California, Oregon and
   Washington, (Number 4091)", McClintock and Leiser, Division of Agricultural Sciences,
   University of California, 1979.

   Association, Inc.


1.03 SUBMITTALS

A. Product Data: Manufacturer’s current catalog cuts and specifications of the following:
   1. Mulch and fertilizer tablets
   2. Anti-desiccant
   3. Tree stakes
   4. Root barrier
   5. Filter fabric

B. Samples:
   1. Mulch: Two (2) pints, each type.
C. Certificates of Inspection: As required by law for transportation of each shipment of plants along with invoice.

D. Results from plant pit drainage tests.

E. Building Product Disclosure and Optimization, Sourcing of Raw Materials:
   1. Option 1: Corporate Sustainability reports for products that comply with LEED requirements for raw material and source extraction reporting. OR

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Do not deliver disease-infected plant materials to the site.

B. Labeling: Furnish standard products in manufacturer’s standard containers bearing original labels legibly showing quantity, analysis, genus/species and name of manufacturer/grower.

C. Storage: Protect metal containers from sun during summer months with temperatures above 80 degrees F. Keep plants that cannot be planted immediately upon delivery in the shade, well protected and well watered.

D. Handling: Do not lift or handle plants by tops, stems or trunks at any time. Do not bind or handle plants with wire or rope at any time (except wrapped rootball of field dug material).

E. Anti-Desiccant: At Contractor’s option, immediately before transporting, spray deciduous plant materials in full leaf or evergreens with anti-desiccant. Apply an adequate film over trunks, branches, twigs and foliage.

1.05 SEQUENCING AND SCHEDULING

A. Acceptance: Do not install plant materials prior to acceptance of finish grades and main line trenching/installation of irrigation system.

B. Coordination: Coordinate with work of other sections to insure the following sequence of events:
   1. General: Sprinkler system to be installed and operable prior to installation of plant materials. Schedule hand watering of all plant materials installed prior to sprinkler irrigation system.
   2. Headers: Install prior to installation of adjacent sprinkler irrigation system.
   3. Vines: Do not attach anchors or ties to wall or other structures prior to acceptance of such work under another Section.
   4. Trees in Paving: As necessary, install prior to installation of paving under another Section. See Drawings.
   5. Pruning: Do not prune plant materials prior to installation and acceptance. Request review by Landscape Architect prior to pruning.
   6. Above-Grade Planters: Install after completion of all waterproofing, drainage, irrigation, and decking. See Architectural Drawings.
1.06 WARRANT

A. Warrant that all trees and shrubs planted under this Contract will be healthy and in flourishing condition of active growth one (1) year from date of Final Acceptance. Similarly warrant perennials, grasses, and groundcover for a period of six (6) months from date of Final Acceptance.

B. Correct Species: Warrant that all plant materials are true to species and variety.

C. Delays: Delays caused by the Contractor in completing planting operations which extend the planting into more than one planting season shall extend the Warranty Period correspondingly.

D. Condition of Plants: Plants shall be free of dead or dying branches and branch tips, with foliage of normal density, size and color.

E. Replacements: As soon as weather conditions permit, replace, without cost to District all dead plants and all plants not in a vigorous, thriving condition, as determined by Landscape Architect during and at the end of Warranty Period.

F. Exclusions: Contractor shall not be held responsible for failures due to neglect by District, vandalism, and acts of Nature, during Warranty Period. Report such conditions.

1.07 CERTIFICATE OF COMPLETION

A. Contractor to provide items required by the Department of Water Resources, Title 23, Chapter 2.7, Model Water Efficient Landscape Ordinance.

B. Items to include, but not be limited to:
   1. Irrigation audit report.
   2. Controller parameter/settings.
   3. Soil sampling analysis results.

1.08 MAINTENANCE PERIOD AND FINAL ACCEPTANCE

A. See Section 32 93 25 - Landscape Maintenance.

1.09 REPLACEMENTS

A. Failed Materials:
   1. Repair and/or replace at no cost to the District all plant materials exhibiting conditions which are determined as unacceptable due to workmanship by the Contractor.
   2. Closely match replacements to adjacent specimens of the same species. Apply requirements of this Specification to replacements.
   3. Contractor shall be held responsible for a maximum of two (2) replacements for each failed tree, shrub and vine, and same area of groundcover planting after final acceptance during warranty period.
B. Incorrect Materials:
1. During Warranty Period, replace at no cost to District plants revealed as being untrue to name and species.
2. Provide replacements of a size and quality to match the planted materials at the time the mistake is discovered.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Plant Materials: Verify that all container stock has been grown in the containers in which delivered for at least one growing season, but not over two (2) years.
1. Growing Conditions: Plants shall be nursery-grown in accordance with good horticultural practices under climatic conditions similar to those of the project for at least two years unless otherwise specifically authorized.
2. Appearance: Trees shall be exceptionally heavy, symmetrical, tightly knit, and so trained or favored in development and appearance as to be superior in form for their species, with regard to number of branches, compactness and symmetry.
3. Vigor: Plants shall be sound, healthy and vigorous, well branched and densely foliated when in leaf. They shall be free of disease, insect pests, eggs, or larvae. They shall have healthy, well-developed root systems. Plants shall be free from physical damage or adverse conditions which would prevent thriving growth.

B. Condition of Root System: Samples must prove to be completely free of circling, kinked, or girdling trunk surface and center roots and show no evidence of a pot-bound condition. Upon inspection by Landscape Architect at the job site, if five (5) percent or more of the plants of each species are found to contain kinked, circling, or girdling roots, all plants of that species will be rejected.

C. Measurements:
1. General: Take caliper measurement at a point on the trunk 6 inches above natural ground line for trees up to 4 inches in caliper (and at a point 12 inches above the natural ground line for trees over 4 inches in caliper.)
   a. Measure foliage across mean foliage dimension when branches are in their normal upright position. Foliage origin along main trunk shall be measured from soil line.
   b. Height and spread dimensions specified refer to main body of plant and not branch tip to tip. Properly trimmed plants shall measure the same in any direction. If a plant is unevenly grown, it shall be classified in the size category of the smallest dimension.
2. Size Range: If a range of size is given, do not use plant materials less than the minimum size. The measurements specified are the minimum size acceptable and are the measurements after pruning, where pruning is required. Plants that meet the measurements specified, but do not possess a normal balance between height and spread shall be rejected.
3. Substitutions: Substituted plants shall be true to species and variety and shall conform to measurements specified except that plants larger than specified may be used if accepted. Use of such plants shall not increase Contract price. If larger plants are accepted, increase the ball of earth in proportion to the size of the plant. Plants overgrown for their container size will be rejected.

D. Unacceptable Trees: Trees which have damaged or crooked leaders will be rejected. Trees having a main leader shall not have been headed back. Trees with abrasions of the bark, sunscalds, disfiguring knots, or fresh cuts of limbs over 3/4 inch which have not completely callused, will be rejected.

E. Pruning: Do not prune plants before delivery. Consult Landscape Architect for pruning after installation.

2.02 MIXES

A. Backfill and Topsoil Mixes for Plant Pits: See Section 32 91 13 - Soil Preparation.

B. Commercial Fertilizers:
   1. Top-dress Fertilizer: For bid purposes -- final mix to be as specified in soils report recommendations. Complete fertilizer, 50 percent of the nitrogen to be derived from natural organic sources or urea-form. Available phosphoric acid shall be from superphosphate, bone or tankage. Potash shall be derived from muriate of potash containing 60 percent potash:
      16% Nitrogen
      6% Phosphoric Acid
      8% Potash

C. Anti-Desiccant/transpirant: Used for retarding excessive loss of plant moisture and inhibiting wilt
   1. Type: Sprayable, water-soluble pine oil complex which will produce a moisture-retarding barrier not removable by rain.
   2. Product: "Wilt-Pruf" by Wilt-Pruf Products, Inc., Greenwich, CT.

2.03 ACCESSORIES

A. Tree Staking:
   1. Type: Round tree stakes, fir, 2-inch diameter x 10-foot length, with a tapered driving point and chamfered top, green color, treated with a copper-based preservative, or approved equal.
   2. Source: D-Stake Mill, 1726 Southwest Highway 18, McMinnville, OR 97128, (800) 528-5525.
   3. Ties: Wonder Tree Ties, by Wonder Tree Tie, Inc. (714) 666-3121, or approved equal.

B. Wood Chip Mulch:
1. Type: Composted redwood bark, free of sticks, dirt, dust and other debris, as accepted by District.
2. Size: ½-inch to ¾-inch diameter.

C. Water:
1. Clean, fresh and potable, furnished and paid for by District.
2. Transport as required.

D. Wood Mulch for Bioretention Basins
1. Type: Shredded redwood bark free of sticks, dirt, dust, and other debris, as accepted.
2. Size: Shredded, gorilla hair style.

E. Tree Root Barrier:
1. Model: Deep Root UB 24-2
2. Color: Black
3. Size: 24” wide x 24” deep

F. Filter Fabric
1. Type: Mirafi 140N, or approved equal.

2.04 SOURCE QUALITY CONTROL

A. Review: Submit a written request for review of plant materials and quantity at place of growth at least sixty (60) calendar days prior to shipment to site. Right is reserved to refuse review at this time if, in his judgment, a sufficient quantity of plants is not available.

B. Distant Material: Submit photographs with a person adjacent to each plant type for preliminary review. Such review shall not impair the right of review and rejection during progress of the work.

C. Unavailable Material: If proof is submitted that a specified plant is not obtainable, a proposal will be considered for use of the nearest equivalent size or variety with corresponding adjustment of Contract price. Substantiate such proof in writing no later than 30 days after award of contract.

D. Special Conditions: The above provisions shall not relieve Contractor of the responsibility of obtaining specified materials in advance if special growing conditions or other arrangements must be made in order to supply specified materials.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verification of Conditions:
1. Finish Grades: Finish grades for planting areas shall have been established in another Section. Verify that all grades are within 1 inch plus or minus of required finish grade.

2. Soil Preparation: Do not commence planting work prior to completion and acceptance of soil preparation.

3. Irrigation: Verify that irrigation system has been installed and accepted.

3.02 PREPARATION

A. Layout and Staking: Lay out plants at locations shown on Drawings for review and approval by District prior to installation. Stake each tree, not specifically located by dimension or alignment.

B. Review: Locations of plants will be checked in the field and will be adjusted to exact position before planting begins. Right is reserved to refuse review at this time if, in the District's opinion, an insufficient quantity of plants is available.

C. Digging Plant Pits: Dig tree pits and scarify all sides of the tree pit after excavation - see below. Do not use an auger or tree spade.

D. Containerized Plant Pits: Excavate square plant pits as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boxed Trees</td>
<td>Box + 24 inches</td>
</tr>
<tr>
<td>Canned Trees</td>
<td>Can + 18 inches</td>
</tr>
<tr>
<td>Canned Shrubs and Vines</td>
<td>Can + 12 inches</td>
</tr>
</tbody>
</table>

3.03 DRAINAGE TEST OF PLANT PITS/OBSTRACTIONS

A. Testing: Immediately after completion of excavation, test drainage of a minimum of eight (8) plant pits by filling with water twice in succession. Give written notification of conditions permitting the retention of water in plant pits for more than twenty-four (24) hours.

B. Correction: Submit for acceptance a written proposal and cost estimate for the correction of poor drainage conditions before proceeding with planting.

C. Obstructions: If rock, underground construction work, tree roots or other obstructions are encountered in the excavation of plant pits, acceptable alternate locations may be used at direction of District.

D. Percolation Test Pit:

1. Location: At tree planting locations, as determined by Landscape Architect on site.

2. Restrictions: Do not perform test on a rainy day. Repeat all tests interrupted by rain or cold.

3. Procedure:
   a. Dig test pit of a size specified for the tree pits, a minimum of 4 feet deep. Legibly calibrate a stake at 1-inch intervals and drive it firmly into the undisturbed soil at the bottom of the pit.
b. Fill test pit with water to within 1 foot of the finish grade. Immediately record water level on the stake.

c. After 3 hours, record water level again. Repeat recording of water level once each hour for the succeeding five hours.

4. Documentation: Submit written documentation of all test pit results, dated and signed by the tester.

3.04 TREE, SHRUB AND VINE PLANTING

A. Handling and De-potting of Plant Materials:

1. Damage: Avoid damage to containers and rootballs. If rootball is cracked or broken during handling and de-potting, plant will be rejected. Do not remove plant from container prior to completion of plant pit preparation.

2. Canned Trees and Shrubs: Cut can on two sides with accepted cutting tool. Do not use spade. Plastic Containers: Tip container to horizontal orientation and shake carefully to remove shrub. Support rootball during installation to prevent cracking or shedding of soil.

3. Boxed Trees: Lift from bottom with forklift or from sides with 2-inch x 4-inch rails nailed to each side of box. Do not remove box prior to settling tree in plant pit. Remove sides of box after acceptance by Landscape Architect and prior to backfilling. Bottom of box may be left in place.

B. Installation:

1. Scarification:
   a. Plant Rootball: After removing plant from container, scarify the sides of the rootball to a depth of 1 inch at four to six equally-spaced locations around the perimeter of the ball or at 12-inch intervals on sides of boxed materials. Cut and remove circling roots over 3/8-inch diameter.
   b. Plant Pit: Scarify sides of plant pit, thoroughly breaking up surfaces and eliminating "glazed" areas.

2. Positioning: Backfill plant pit to allow setting crown of tree 2 inches above new finish grade and crown of shrub 1 inch above finish grade. Thoroughly foot tamp all backfill. Position plant in planting pit, maintaining plumb condition. Maintain throughout all planting operations.

3. Backfilling:
   a. Use backfill mix to backfill plant pits as shown on Drawings. Brace each plant plumb and rigidly in position until planting soil has been tamped solidly around the ball and roots.
   b. When plant pits have been backfilled approximately 2/3 full, water thoroughly and saturate rootball, before installing remainder of the backfill mix to top of pit, eliminating all air pockets.

4. Staking: When required, stake or as specified below.

5. Slow-release Fertilizer Tablets: Place evenly distributed in plant pits.
   - 1 gallon can - 2 tablets
   - 5 gallon can - 4 tablets
   - 15 gallon can - 6 tablets
   - 24 in. box - 8 tablets
   - 36 in. box - 10 tablets
   - 48 in. box - 12 tablets

C. Watering Basin: Form saucer with 3-inch high berm centered around tree and shrub pits 12 inches wider than ball diameter.
D. Watering: Immediately water all plants after completion of planting operations.

3.05 STAKING

A. Remove nursery-supplied stake and install ‘Wonder Tree Tie’ per manufacturer’s recommendations. Find proper height for point of tree tie and attach as follows:
   1. Hold trunk in one hand, pull top to one side and release. Height at which trunk will snap back to upright position while hand-held is Base Height. Attach tree ties to trunk 6 in. above Base Height.
   2. If trunk is too "whippy" to support tree plumb, use auxiliary stake as follows:
      a) Attach auxiliary stake as required to support trunk. Extend stake 30 in. below finish grade up to a point no closer than 24 in. from top of leader.
      b) Round and wrap the ends of the stake with friction tape. Attach stake to trunk with 1 in. wide vinyl or polyethylene tape at 10 in. to 15 in. intervals.

3.06 PRUNING: See Section 32 93 25 - Landscape Maintenance.

3.07 MULCHING

A. Install a 3-inch-deep layer of mulch over all planting areas and as detailed in Drawings. Do not allow mulch to cover crown of shrubs or come within a 12-inch diameter of tree trunks.

B. Install a 3-inch-deep layer of gorilla hair mulch at all detention basins. All other landscape areas and bare ground within project area to receive wood chip mulch.

3.08 GROUNDCOVER PLANTING

A. Top-dress Fertilizer: Apply at the rate of 5 pounds per 1,000 square feet immediately after completion of planting.

B. Watering: Immediately water groundcover areas after fertilizer application to wash fertilizers from leaves of plants.

END OF SECTION
SECTION 32 93 25
LANDSCAPE MAINTENANCE

PART 1 - GENERAL

1.01 SUMMARY

A. Work Included: Provide continuous Landscape Maintenance, complete as specified during progress of the work, after installation, and for a period of 90 days after Preliminary Acceptance.

B. Related Work:
1. Sustainable Design Requirements (LEED) - Section 01 81 13
2. Existing Plants to Remain - Section 31 12 00
3. Irrigation System - Section 32 84 00
4. Soil Preparation - Section 32 91 13
5. Lawns and Grasses - Section 32 92 00
6. Planting - Section 32 93 00

1.02 REFERENCES

A. University of California Cooperative Extension Publications:


1.03 SUBMITTALS

A. Quality Control Submittals:
1. Schedule of maintenance operations and monthly status report including list of equipment, materials proposed for the job and watering schedule.
2. Licenses, permits and insurances required by the District, the State, or Federal government pertaining to maintenance work.
3. Monthly record of all herbicides, insecticides and disease control chemicals used for the project.
4. Documentation of existing planting and irrigation system.
5. Written application recommendation by a licensed agricultural pest control advisor for all weed, pest and disease controls restricted by the Director of Agriculture proposed for this work.

B. Project Close-out Submittal: Include in a single, 3-ring binder a landscape maintenance manual containing an indexed collection of all schedules, records and permits listed above, as well as a documentation of accepted condition of planting and irrigation at Final Acceptance.
1.04 QUALITY ASSURANCE

A. Qualifications:
   1. Experience: The landscape contractor or maintenance subcontractor shall have a full-time employee assigned to the job as foreman for the duration of the contract. He/she shall have a minimum of four (4) years experience in landscape maintenance supervision, with experience or training in entomology, pest control, soils, fertilizers, and plant identification.
   2. Labor Force: The landscape maintenance labor force shall be thoroughly familiar with, and trained in, the work to be accomplished and shall perform the task in a competent, efficient manner acceptable to the District’s Representative.

B. Requirements:
   1. Supervision: The foreman shall directly supervise the work force at all times. Notify District’s Representative of all changes in supervision.
   2. Identification: Provide proper identification at all times for landscape maintenance firm’s vehicles and labor force. Be uniformly dressed in a manner satisfactory to the District’s Representative.

1.05 PROJECT/SITE CONDITIONS

A. Site Visit: At beginning of maintenance period, visit and walk the site with the District's Representative to clarify scope of work and understand existing project/site conditions.

B. Documentation of Conditions: Document general condition of existing trees, shrubs, vines, groundcovers and lawn recording all plant materials which are healthy, thriving, damaged, dead or dying.

C. Irrigation System: Document general condition of existing irrigation system, making sure that faulty electrical controllers and broken or inoperable sprinkler heads or emitters are reported.

1.06 SEQUENCING AND SCHEDULING

A. Perform all maintenance during hours mutually agreed upon between District’s Representative and Contractor.

B. Work force shall be present at the project site at least once a week and as often as necessary to perform specified maintenance in accordance with the approved maintenance schedule.

1.07 WARRANTY

A. Specific Requirements: Refer to the following sections:
   1. Irrigation - Section 32 84 00.
   2. Lawns and Grasses - Section 320 92 00.
   3. Planting - Section 32 93 00.
PART 2 - PRODUCTS

2.01 MATERIALS

A. General: All materials and equipment shall be provided by the Contractor, except as specified below.

B. Water: Clean, potable and fresh, as available from District.

C. Fertilizers:
   1. Tightly-compressed, slow-release and long-lasting complete fertilizer tablets bearing manufacturer's label of guaranteed analysis of chemicals present.
   2. Balanced, once-a-season application, controlled-release fertilizers with a blend of coated prills which supply controlled-release nitrogen, phosphorus and potassium, and uncoated, rapidly soluble prills containing nitrogen and phosphorus.

D. Herbicides, Insecticides, and Fungicides:
   1. Best quality materials with original manufacturers' containers, properly labeled with guaranteed analysis. Coordinate all use with District's Representative prior to application.
   2. Use non-staining materials.

2.02 EQUIPMENT

A. General: Use only the proper tool for each job. Maintain all tools in sharp, properly-functioning condition. Clean and sterilize pruning tools prior to usage.

B. Insect/Disease Prevention: Take all acceptable measures to prevent introduction of insect or disease-laden materials onto the site. Planting - Section 32 93 00.

PART 3 - EXECUTION

3.01 ESTABLISHING THE MAINTENANCE PERIOD

A. Preliminary Review: As soon as planting is substantially completed per documents, hold a preliminary review to determine the condition of the work.

B. Date of Review: Notify District Representative at least five (5) workings days prior to anticipated date of review.

C. Beginning of the Maintenance Period: The date on which the District Representative issues a letter of Preliminary Acceptance to the Contractor.

3.02 PREPARATION

A. Protection:
   1. Protect all new planting areas from damage of all kinds from beginning of work until sufficiently established or until Final Acceptance.
   2. Provide temporary protection fences, barriers and signs as required for protection.
B. Replacements:
   1. Immediately treat or replace all plants which become damaged or injured as a result of Contractor's operations or negligence, as directed by District Representative, at no cost to District.
   2. Replacement plants shall match size, condition and variety of plants replaced.

3.03 PLANTING

A. Watering Basins:
   1. Maintain all watering basins around plants so that enough water can be applied to establish moisture through major root zones.
   2. For supplemental hand watering of watering basins, use a water wand to break the water force. Do not permit use of "jet" type watering equipment. Do not permit crown roots to become exposed to air through dislodging of soil and mulch.
   3. Maintain originally called for depth of mulch to reduce evaporation and frequency of watering.
   4. In rainy season, open basins to allow surface drainage away from the root crown where excess water may accumulate. Restore watering basins at end of rainy season.

B. Resetting: Reset plants to proper grades and upright position.

C. Weed Control:
   1. All areas between plants, including watering basins, shall be weed free at all times.
   2. Use only recommended and legally approved herbicides to control weed growth.
   3. Avoid frequent soil cultivation that destroys shallow roots.

D. Pruning:
   1. Prune trees to select and develop permanent scaffold branches that are smaller in diameter than the trunk or branch to which they are attached, and which have vertical spacing of 18 inches to 48 inches and radial orientation so as not to overlap one another.
   2. Prune trees to eliminate diseased or damaged growth, and narrow V-shaped branch forks that lack strength. Reduce toppling and wind damage by thinning out crowns.
   3. Prune trees to maintain growth within space limitations, maintaining a natural appearance and balancing crown with roots.
   4. No stripping of lower branches ("raising up") of young trees will be permitted.
   5. Retain lower branches in a "tipped back" or pinched condition to promote caliper trunk growth (tapered trunk). Do not cut back to fewer than six buds or leaves on such branches. Only cut lower branches flush with the trunk after the tree is able to stand erect without staking or other support.
   6. Thin out and shape evergreen trees when necessary to prevent wind and storm damage. Do primary pruning of deciduous trees during the dormant season. Do not permit any pruning of trees prone to excessive "bleeding" during growth season.
   7. Prune damaged trees or those that constitute health or safety hazards at any time of year as required.
8. Make all cuts clean and close to the trunk, without cutting into the branch collar. "Stubbing" will not be permitted. Cut smaller branches flush with trunk or lateral branch. Make larger cuts (1 inch in diameter or larger) parallel to shoulder rings, with the top edge of the cut at the trunk or lateral branch.

9. Branches too heavy to handle shall be precut in three stages to prevent splitting or peeling of bark. Make the first two cuts 18-inches or more from the trunk to remove the branch. Make the third cut at the trunk to remove the resulting stub.

10. Do not prune or clip shrubs into balled or boxed forms unless specifically called for by design.

11. Clip shrubs to be hedged when branches project 2 inches beyond limit of clipped hedge shown on the Drawings.

12. Take extreme care to avoid transmitting disease from one infected plant to another. Properly sterilize pruning tools before going from one infected plant to all other plants.

E. Staking and Guying of Trees:
1. Inspect stakes and guys at least once a month to check for rubbing that causes bark wounds.
2. Conform to the recommended procedures of staking and guying as outlined in the University of California Publication AXT-311, "Staking Landscape Trees."

F. Maintenance of Existing Plantings to Remain:
1. General: Conform to all applicable paragraphs regarding watering, spraying, and fertilizing of new plant materials as specified in this Section.
2. Symptoms: Be alert to symptoms of construction damage to existing plantings as evidenced by wilting, unseasonal or early flowering or loss of leaves, and insect or disease infestation due to declining vigor.
3. Notification: Submit in writing of evidences of declining vigor immediately upon discerning the problem. Take appropriate interim measures to mitigate the severity of the problem as specified in this Section.
4. Proposal: Submit written proposal and cost estimate for the correction of all conditions before proceeding with permanent correction work.

3.04 GROUNDCOVERS

A. Watering:
1. Check for moisture penetration throughout the root zone at least twice a month.
2. Water as frequently as necessary to maintain healthy growth of groundcovers.

B. Weed Control:
1. Control weeds, preferably with pre-emergent herbicides and with selective systemic herbicides.
2. Minimize hoeing of weeds in order to avoid plant damage.

C. Fertilization:
1. Recently installed plant materials: Verify with Owner actual completion date of planting installation and rate of prior application of fertilizers.
2. New plant materials: Place one (1) 5-gram tablets (20-10-5; N-P-K) beside the root ball about an inch from root tips.
3. Established Plant Materials: Do not use complete fertilizers unless soil test shows specific nutrient deficiencies.
D. Mowing and Edging:
   1. Edge groundcovers to keep in bounds. Trim top growth as necessary to achieve an overall even appearance.
   2. Groundcovers which lend themselves to mowing shall be mowed to specified height above finished grade in order to renew growth, improve density and attractiveness.

E. Replace dead and missing plants after obtaining Owner's agreement to pay for replacement. Damages due to Contractor's negligence shall be paid for without charge to Owner.

3.05 GRASSES

A. Watering:
   1. Check for moisture penetration throughout the root zone at least twice a month using a moisture sensor and soil probe.
   2. Water as frequently as necessary to maintain healthy growth.

B. Weed Control:
   1. Control weeds, preferably by hand without the use of herbicides.
   2. Minimize hoeing of weeds in order to avoid plant damage.

C. Fertilization:
   1. Recently installed plant materials: Verify with District Representative actual completion date of planting installation and rate of prior application of fertilizers.
   3. Established Plant Materials: Do not use complete fertilizers unless soil test shows specific nutrient deficiencies.

D. Replace dead and missing plants after obtaining District's agreement to pay for replacement if outside warranty period. Damages due to Contractor's negligence shall be paid for without charge to District.

3.06 INSECTS, PESTS, AND DISEASE CONTROL

A. Inspection: Inspect all plant materials for signs of stress, damage and potential trouble from the following:
   1. Presence of insects, moles, gophers, ground squirrels, snails and slugs in planting areas.
   2. Discolored or blotching leaves or needles.
   3. Unusually light green or yellowish green color inconsistent with normal green color of leaves.

B. Personnel: Only licensed, qualified, trained personnel shall perform spraying for insect, pest and disease control

C. Application: Spray with extreme care to avoid all hazards to any person or pet in the area or adjacent areas.
3.07 IRRIGATION SYSTEM

A. General:
   1. Repair without additional charge to District all damages to system caused by Contractor's operations. Perform all repairs within one (1) watering period.
   2. Report promptly to District all accidental damage not resulting from Contractor's negligence or operations.
   3. Monitor and generally do not run the irrigation system during rainy season. Set and program automatic controllers for seasonal water requirements.
   4. Twice a month, use a probe or other acceptable tool to check the rootball moisture of representative plants as well as the surrounding soil.

B. Cleaning and Monitoring the System:
   1. Continually monitor the irrigation systems to verify that they are functioning properly as designed. Make program adjustments required by changing field conditions.
   2. Clean pump filter and strainer at least once a year and as often as necessary to keep the irrigation systems free of sand and other debris.
   3. Prevent spraying on windows, building walls, and pathway by balancing the throttle control on the remote control valves and the adjustment screws on the sprinkler heads. Do not allow water to atomize and drift.

3.08 TERMINATION OF THE MAINTENANCE PERIOD

A. Final Acceptance Procedure:
   1. Work will be accepted by the District Representative upon satisfactory completion of all work, including maintenance period, but exclusive of replacement of materials under the Warranty Period.
   2. Submit a written request to District Representative for review for Final Acceptance at least five (5) working days prior to anticipated Final Review date, which is at the end of the Maintenance Period.

B. Corrective Work:
   1. Work requiring corrective action or replacement shall be performed within ten (10) calendar days after the Final Review.
   2. Perform corrective work and materials replacement in accordance with the Drawings and Specifications, and shall be made by the Contractor at no cost to the District.
   3. After corrective work is completed, the Contractor shall again request a Final Review for Final Acceptance as outlined above.
   4. Continue maintenance of all landscaped areas until such time as all corrective measures have been completed and accepted.

C. Conditions for Acceptance of Work at End of Maintenance Period:
   1. Each plant shall be alive and thriving, showing signs of growth and no signs of stress, disease, or any other weaknesses.
   2. Replace all plants not meeting these conditions. An additional Warranty Period equal in length to the original shall be commenced for all such plants and planted areas.
D. Final Acceptance Date: The date on which the District Representative issues a Letter of Final Acceptance. Upon Final Acceptance, the District will assume responsibility for maintenance of the work.

3.09 CLEANING

A. Dispose of all pruned materials, remove all debris, and sweep all walkways.

B. Remove from the site all containers and evidence of maintenance activities.

3.10 CLOSE OUT

A. Landscape Maintenance Record: Submit binder to District with all documentation and records required and utilized during the maintenance period.

B. Keys and Identification: Return all keys and identification materials supplied by District for the purpose of site access.

END OF SECTION
SECTION 33 11 66
WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Site water distribution system for irrigation water, domestic water and fire protection service up to 5 feet of any on-site commercial building being served.

B. Irrigation water, domestic water and fire protection water transmission or distribution system within a roadway or street right-of-way.

C. Protective coating or wrap for metallic pipe, fittings, restraining devices, and appurtenances

1.02 RELATED SECTIONS

A. Section 31 23 33, Utility Trenching and Backfilling.

1.03 RELATED DOCUMENTS

A. ASTM:
   2. B 88: Specifications for Seamless Copper Water Tube.
   3. D 1785: Specifications for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

B. AWWA:
   3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water.
   9. C200: Steel Water Pipe-6 In. (150 mm) and larger.
   12. C207: Steel Pipe Flanges for Waterworks Service-Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
19. C219: Bolted, Sleeve-type Couplings for Plain-End Pipe.
24. C507: Ball Valves 6 In. Through 8 In. (150 mm Through 1,200 mm).
25. C508: Swing-check Valves for Waterworks Service, 2 In. (50mm) Through 24 In. (600 mm) NPS.
27. C510: Double Check Valve Backflow-Prevention Assembly.
28. C511: Reduced-Pressure Principle Backflow-Prevention Assembly.
33. C606: Grooved and Shouldered Joints.
34. C651: Disinfecting Water Mains.
36. C900: Polyvinyl Chloride (PVC) Pressure Pipe and Fittings, 4 In. Through 12 In. (100mm Through 300mm) for Water Distribution.
37. C901: Polyethylene (PE) Pressure Pipe and Tubing, ½ In. (13mm) Through 3 In. (76mm) for Water Service.
38. C905: Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. Through 48 In. (350 mm Through 1,200 mm) for Water Transmission and Distribution.
39. C906: Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 63 In (1,575 mm), for Water Distribution and Transmission.
40. C907: Polyvinyl Chloride (PVC) Pressure Fittings for Water – 4 In. through 8 In. (100 mm Through 200 mm).
44. M41: Ductile-Iron Pipe and Fittings.

1.04 REGULATORY REQUIREMENTS

A. Contra Costa Water District Standard Details and Specifications

B. Contra Costa County Fire Protection District Standard Details and Specifications
1.05 DEFINITIONS

A. AASHTO: American Association of State Highway and Transportation Officials.


C. AWWA: American Waterworks Association

D. DI: Ductile iron.

E. DIP: Ductile iron pipe.

F. FM: Factory Mutual.


H. NSF: National Sanitation Foundation.


J. PE: Polyethylene.

K. PVC: Polyvinyl Chloride.

L. UL: Underwriters Laboratory.

1.06 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Internal Pressures
   2. Test Pressure: 200-psi.

B. External Load: Earth load indicated by depth of cover plus AASHTO H20 live load unless indicated otherwise.

1.07 SUBMITTALS


B. Product Data: For the following:
   1. Piping materials and fittings.
   2. Pipe couplings.
   3. Flexible pipe fittings.
   4. Restrained pipe fittings.
   5. High deflection fittings/ball joints.
   7. Flexible expansion joints.
   8. Gate valves.
  10. Check valves.
  11. Air and vacuum relief valves.
13. Pressure reducing valves.
14. Pressure sustaining valves.
15. Ball valves.
16. Fire hydrants.
17. Post indicator valves.
18. Fire department connections.
20. Precast valve boxes and box covers.

C. Shop drawings: Include plans, elevations, details and attachments to be reviewed and approved by the Contra Costa County Fire Protection District
   1. Precast and cast in-place vaults and covers.
   2. Wiring diagrams for alarm devices.

D. Field test reports: Indicate and interpret test results for compliance with the Project requirements.

1.08 QUALITY ASSURANCE

A. Comply with requirements of utility supplying water. Do not operate existing valves or tap existing piping without written permission and/or presence of utility company representative.

B. Comply with the following requirements and standards:

C. Provide listing/approval stamp, label, or other marking on piping and specialties made to a specified standard.

1.09 MATERIAL DELIVERY, STORAGE AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
   1. Ensure that valves are dry and internally protected against rust and corrosion.
   2. Protect valves against damage to threaded ends and flange faces.

B. Deliver piping with factory-applied end-caps. Maintain end-caps through shipping, storage and handling to prevent pipe end damage and to prevent entrance of dirt, debris and moisture.

C. Handling: Use slings to handle valves and fire hydrants whose size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
D. During Storage: Use precautions for valves, including fire hydrants according to the following.
   1. Do not remove end protectors, unless necessary for inspection, then reinstall for storage.
   2. Protection from Weather: Store indoors and maintain temperature higher than ambient dew-point temperature. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

E. Do not store plastic pipe and fittings in direct sunlight.

F. Protect pipe, fittings, flanges, seals and specialties from moisture, dirt and damage.

G. Protect linings and coatings from damage.

H. Handle precast boxes, vaults and other precast structures according to manufacturer’s written instructions.

I. Protect imported bedding and backfill material from contamination by other materials.

1.10 COORDINATION

A. Coordinate connection to existing water mains with water utility supplying water.

B. Coordinate piping materials, sizes, entry locations, and pressure requirements with building domestic water distribution piping and fire protection piping.

1.11 HAZARDOUS MATERIAL – ASBESTOS CONCRETE PIPE AND ASBESTOS CONTAINING MATERIAL

A. Asbestos cement pipe (ACP) exists within the project area and replacement of existing ACP is anticipated but shall be abandoned in place unless otherwise noted in the plans. The contractor shall make every attempt to protect all asbestos containing items during the execution of this contract. However, there will be instances where ACP or asbestos containing material will need to be removed, handled, cut, disturbed, or disposed of and the contractor shall comply with all local, state and federal regulations regarding construction activities near asbestos containing materials.

PART 2 - PRODUCTS

2.01 LARGE SIZE SERVICE AND DISTRIBUTION PIPES

A. PVC Pipe: Sizes 4-inch through 48-inch.
   1. Pipe:
      a. 4-inch through 12-inch: AWWA C900.
      b. 14-inch through 48-inch: AWWA C905.
   2. Fittings: DI
   3. Unrestrained Joints:
   4. Restrained Joints:
      a. Push-On Bell and Spigot Joint: Harness assembly as manufactured by Ebaa
Iron (Eastland, Tx) (Tel. 800-433-1716) or approved equal.
b. Plain End PVC to DI Mechanical Joint: Ebaa Iron (Eastland, Tx) (Tel. 800-433-1716) or approved equal.

5. Steel or Ductile Iron Couplings:
a. Plain End Pipe to Plain End Pipe: Ductile iron or steel bolted couplings, manufacturer’s shop coating with low alloy steel bolts and nuts. Steel couplings to conform to AWWA C219. Smith-Blair, Inc, (Texarkana, AR) (Tel. 501-773-5127). Dresser (Bradford, PA) (Tel.-814-368-3131) or approved equal.
b. Plain End Pipe to DI or Steel Flanged Pipe: Ductile iron or steel bolted flanged coupling adapters, manufacturer’s shop coating with low alloy steel bolts and nuts. Steel flanged couplings to conform to AWWA C219. Smith-Blair, Inc, (Texarkana, AR) (Tel. 501-773-5127), Dresser (Bradford, PA) (Tel.-814-368-3131) or approved equal.

6. PVC Couplings
a. Unrestrained Plain End to Plain End Pipe: AWWA C900, as manufactured by CertainTeed (Valley Forge, PA) (Tel. 610 341-6820) or approved equal.
b. Restrained Plain End to Plain End Pipe: AWWA C900, “Certa-Lock” as manufactured by CertainTeed (Valley Forge, PA) (Tel. 610 341-6820) or approved equal.

2.02 CORROSION PROTECTION

A. All ductile iron fittings shall be protected against corrosion with the installation of corrosion protection wrapping.

B. POLY-WRAP AND POLYETHYLENE ADHESIVE TAPE
1. Poly-wrap shall be continuous tubing formed from 8-mil (0.2-mm) thick virgin polyethylene, in accordance with AWWAC105. Minimum polyethylene tube size shall be as follows:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>POLY-WRAP FLAT TUBE WIDTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 to 8 inches (100 to 200 mm)</td>
<td>(100 through 200mm)</td>
</tr>
<tr>
<td>21&quot; (530mm)</td>
<td>10&quot; through 12&quot;</td>
</tr>
<tr>
<td>10&quot; through 12&quot;</td>
<td>(250 through 300mm)</td>
</tr>
<tr>
<td>29&quot; (735mm)</td>
<td>14&quot; through 16&quot;</td>
</tr>
<tr>
<td>14&quot; through 16&quot;</td>
<td>(350 through 400mm)</td>
</tr>
<tr>
<td>37&quot; (940mm)</td>
<td></td>
</tr>
</tbody>
</table>

2. Adhesive tape shall be a general-purpose polyethylene adhesive tape, 2-inches (50-mm) wide and at least 8 mil (0.2mm) thick.
2.03 HIGH DEFLECTION FITTINGS/BALL JOINTS
   A. Plain End Pipe: Xtra Flex Restrained Joint High Deflection Fittings, 4-inch through 24-inch, U. S. Pipe, (Birmingham, AL) (Tel. 205-254-7442) or approved equal.
   B. Mechanical or Flanged Joint: Flex 900, 4-inch through 12-inch, Ebaa Iron Sales, (Eastland, TX) (Tel. 800-433-1716) or approved equal.

2.04 EXPANSION JOINTS
   A. TR Flex Joints: TR Flex Telescoping Sleeve, 4-inch through 64 inch, U. S. Pipe, (Birmingham, AL) (Tel. 205-254-7442).
   B. Mechanical or Flanged Joint: Ex-Tend 200, 4-inch through 36-inch, EBAA Iron Sales, (Eastland, TX) (Tel. 800-433-1716) or approved equal.

1.1 FLEXIBLE EXPANSION JOINTS
   C. Plain End to Plain End Pipe: “Xtra Flex,” sizes 4-inch through 24-inch, U. S. Pipe, (Birmingham AL) (Tel. 205-254-7442) or approved equal.
   D. Flanged or mechanical Joint: “Flex-Tend,” sizes 3-inch through 48-inch, Ebaa Iron (Eastland TX) (Tel. 800-433-1716) or approved equal.
   E. Flanged Joint: Starflex, Series 500, Star Pipe Products, (Tel. 800-999-3009) or approved equal.

2.05 SERVICE LINE VALVES AND FITTINGS
   A. General: AWWA C-800
   B. Includes service lines, ½ inch through 2 inch, from main to meter valve, including corporation stops and curb stops.

2.06 GATE VALVES
   A. Provide on lines 10-inch and smaller.
   B. Valves, 3-Inch through 20-Inch: AWWA C509, resilient-seated, non-rising stem, gray or ductile-iron body and bonnet, with bronze or gray or ductile-iron gate, bronze stem and square stem operating nut unless noted otherwise. All bolts, nuts and washers, except operating nut, shall be stainless steel. Stem operating nut to be 2-inches square and open counter-clockwise. Stem extensions shall be installed to bring the stem operating nut to within 2-feet of finish grade where the depth from finish grade to the stem operating nut exceeds 4-feet. Equip valves in pump stations and other interior or vault installations with hand-wheels. Provide protective epoxy interior and exterior coating according to AWWA C550 and manufacturer’s recommendations.
   C. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
1. Mueller Company (Decatur, IL) (Tel. 800-423-1323).
3. Clow

D. Valve Box and Cover: 9-inch minimum diameter PCC box with extensions of length required for depth of bury of valve, and cast iron or ductile iron cover with lettering “WATER”. Both the box and the cover shall be rated for AASHTO H20 loading.

2.07 AIR RELEASE, AIR/VACUUM AND COMBINATION AIR VALVES
A. AWWA C512, specific type of valve, size, details and valve box as indicated.
B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Apco Valves, Valve and Primer Corporation (Schaumburg, IL) (Tel. 708-529-9000).
   2. Crispin.

2.08 BLOW-OFF VALVES
A. Blow-off valve assemblies, details and boxes as indicated.

2.09 SWING CHECK VALVES
A. Valves 2-Inch through 24-Inch: AWWA C508, details as indicated.
B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Mueller Company (Decatur, IL) (Tel. 800-423-1323).

2.10 BALL VALVES
A. Valves 6-Inch through 48-Inch: AWWA C507, details as indicated.
B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:

2.11 PRESSURE-REGULATING VALVES
A. Valve: Automatic, pilot-operated, cast-iron body with interior coating according to AWWA C550. 250-psi Working-pressure, bronze pressure-reducing pilot valve and tubing, and means for discharge pressure adjustment. Details as indicated.
B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
1. Cla-Val Company (Newport Beach, CA) (Tel. 714-548-2201).
2. Bermad (Porterville, CA) (Tel. 209-781-6630).
3. Ames Company (Woodland, CA) (Tel. 916-666-2493).

2.12 FLOW-REGULATING VALVES

A. Valve: Automatic, pilot-operated, cast-iron body with interior coating according to AWWA C550. 250-psi working-pressure, bronze pressure-reducing pilot valve and tubing, and means for flow adjustment. Details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Cla-Val Company (Newport Beach, CA) (Tel. 714-548-2201).
   2. Bermad (Porterville, CA) (Tel. 209-781-6630).
   3. Ames Company (Woodland, CA) (Tel. 916-666-2493).

2.13 SERVICE CONNECTIONS AND WATER METERS

A. Service connections and water meter details and boxes per current Contra Costa Water District standard details.

2.14 FIRE HYDRANTS

A. Wet Barrel: AWWA C503, details as indicated.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Clow (800 Series) Model 860
   2. Clow (Ranger) Model 960
   3. Jones Model J-3760

C. Available Paint Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Kelly Moore – Kel Guard Enamel “Sunburst/Safety Yellow” No 1700-63
   2. Sherman Williams – Metalex “Safety Yellow” No.B42Y37

2.15 REDUCED PRESSURE ASSEMBLY BACKFLOW PREVENTER – IRRIGATION AND DOMESTIC

A. Provide as indicated and as required by State or local agency.

B. General: AWWA C511, with OS gate valve on inlet and outlet, and strainer on inlet. Include test cocks and pressure-differential relief valve with ASME A112.1.2 air gap fitting located between 2 positive-seating check valves for continuous-pressure application.

C. Body:
   1. 2-Inch and Smaller: Bronze with threaded ends.
2. 2-1/2-Inch and Larger: Bronze, cast iron steel, or stainless steel with flanged ends.

D. Interior Lining: AWWA C550, epoxy coating for cast iron or steel bodies.

E. Interior Components: Corrosion-resistant materials.

F. Manufacturer shall be approved by Contra Costa Water District, Materials List Attached.

2.16 DOULBE DETECTOR CHECK BACKFLOW PREVENTER – FIRE

A. FM approved or UL listed, with OS&Y gate valve on inlet and outlet, and strainer on inlet. Include two positive-seating check valves and test cocks, and bypass with displacement-type water meter, valves, and double-check backflow preventer, for continuous pressure application.

B. Manufacturer shall be approved by Contra Costa Water District. Materials List Attached.

2.17 POST INDICATOR VALVE

A. General: UL 789, FM approved, vertical-type, cast-iron body with operating wrench extension rod, and adjustable cast-iron barrel of length required for depth of bury of valve.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   1. Mueller Co. (Decatur, IL) (Tel.800-423-1323).
   2. Clow Corporation (Oskaloosa, IA).

2.18 FIRE DEPARTMENT CONNECTION

A. Exposed, Freestanding Fire Department Connection: UL 405, cast brass body with threaded inlets according to NFPA 1963 and matching local fire department hose threads and threaded bottom outlet. Include lugged caps, gaskets and chains; lugged swivel connections and drop clapper for each hose-connection inlet; 18-inch high brass sleeve; and round escutcheon plate. Two 2-1/2-inch NPS inlets and 4-inch NPS outlet.

2.19 UNDERGROUND VAULTS/PITS

A. General: Portland cement concrete, precast or cast-in-place as indicated.

B. Portland Cement Concrete and Reinforcing Steel: Section 32 05 23.

C. Access Openings: As indicated.

D. External Load: Earth load plus AASHTO H20 live load if located in traffic area.

2.20 TRACER WIRE

A. General: Minimum #12 AWG stranded copper wire with blue THW, THWN, or THHN rated insulation.
2.21 WARNING TAPE
A. General: Non-detectable 3-inch warning tape made of solid blue film with continuously printed black-letter message reading “CAUTION—WATER LINE BURIED BELOW.”

2.22 PCC THRUST BLOCKS
A. Portland Cement Concrete and Reinforcing Steel: Section 32 05 23.

PART 3 - EXECUTION

3.01 PIPE INSTALLATION
A. General: Install pipe, fittings, and appurtenances utilizing best practices, manufacturer’s instructions, and in accordance with the following:
   1. PVC pipe: AWWA M23 and AWWA C605.

B. Pipe Depth and Trench Configuration: Conform to elevations, profiles and typical trench section(s) indicated.

C. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33.

D. Handling: Carefully handle during loading, hauling, unloading and placing operations to avoid breakage or damage. Use strap type slings for lifting and placing; no chains or hooks will be permitted. Comply with manufacturer’s recommendations.

E. Laying: Before lowering pipe into the trench, remove all stakes, debris, loose rock and other hard materials from the bottom of the trench. Lay accurately in conformance with lines and grades indicated. Lay pipe on a bed of bedding material specified and prepared by handwork, dug true to grade. Furnish firm bearing for pipe throughout its entire length with bell holes provided at the ends of each pipe length of sufficient size to permit making up the particular type of joint being used. Adjust pipe to line and grade by scraping away or filling and tamping material under the body of the pipe for the entire pipe length and not by blocking or wedging. After final positioning, hold pipe in place in trench with backfill material placed equally on both sides of the pipe at as many locations as required to hold the pipe section in place.

F. Curved Alignment: When necessary to conform to the alignment specifically indicated, lay pipe on a curved alignment by means of asymmetrical closure of joints or bending of the pipe barrel. If necessary, use shorter than the standard lengths of pipe to achieve curvature specified. Do not exceed the recommendations of the pipe manufacture for deflections at the joints or pipe bending.

G. Closure: Close open ends of pipes and appurtenance openings at the end of each days work or when work is not in progress.

3.02 CONNECTING TO EXISTING MAINS
A. Pressure Tap Connections: Perform in accordance with the requirements of the owner of the system being tapped. Maintain a positive pressure flow from the main being...
tapped to the tapping device to flush plastic chips, metal ribbons, etc. into the tapping devise and not into the pipe being tapped.

B. Other Connections: As indicated and in accordance with the requirements of the owner of the line being connected to.

3.03 ANCHORAGE INSTALLATION

A. Mechanically Restrained Joints: Install where indicated for lengths indicated in accordance with manufacturer’s instructions.

B. PCC Thrust Blocks: Install where required and as indicated. Bearing area indicated is to be against undisturbed earth. Allow a minimum of 24-hours curing time before introducing water into the pipeline and allow a minimum of 7-days curing time before pressure testing.

3.04 HIGH DEFLECTION FITTINGS/BALL JOINTS, EXPANSION JOINTS, AND FLEXIBLE EXPANSION JOINTS

A. Install as indicated and in accordance with the manufacturers recommendations.

3.05 VALVE INSTALLATION

A. Install all valves in accordance with the manufacturer’s instructions and the following:
   1. General:
      a. Gate Valves: Appendix A of AWWA C509.
   2. Joints:
      b. Valves on Steel Pipe: As indicated for buried locations. Flanged-end valves for installation in vaults/pits.

3.06 SERVICE CONNECTIONS INSTALLATION

A. Install as indicated and in accordance with the requirements of the owner of the system.

3.07 WATER METER INSTALLATION

A. Installed by Contra Costa Water District. Contractor shall coordinate installation.

3.08 FIRE HYDRANT INSTALLATION

A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.09 REDUCED-PRESSURE PRINCIPLE ASSEMBLY BACKFLOW PREVENTER INSTALLATION

A. Install as indicated and in accordance with the requirements of the owner of the system and the local health department requirements.
3.10 DOUBLE CHECK DETECTOR ASSEMBLY INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.11 POST INDICATOR VALVE INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATION
A. Install as indicated and in accordance with the requirements of the owner of the system and the fire department.

3.13 UNDERGROUND VAULT/PIT INSTALLATION
A. Install as indicated.
B. Excavation and Backfill: Section 31 23 33.

3.14 TRACER WIRE INSTALLATION
A. Place and secure to top of pipe and fittings at about 3-foot intervals with 6” length of 1” wide filament tape, Scotch brand No. 898 or equal.
B. Form a mechanically and electrically continuous line throughout the pipeline, extending to the nearest valve or other pipeline appurtenance designated by the owner of the system or the Owner’s Representative. Extend the wire up the outside of the valve box/riser and cut a hole that is 8-inches from the top, extend a 12-inch wire lead to the inside of the box. At other pipeline appurtenances, designated by the owner of the system or the Owner’s Representative, terminate the 12-inch wire lead inside the enclosure.
C. Splice wire with a splicing device consisting of and electro-tin plated seamless copper sleeve conductor. Install as recommended by the manufacturer. Wrap splices and damaged insulation with electrician’s tape.

3.15 WARNING TAPE INSTALLATION
A. Install tape approximately 1-foot above and along the centerline of the pipe.
B. Where tape is not continuous, lap tape ends a minimum of 2-feet.

3.16 PLASTIC PROTECTIVE WRAPPING FOR DUCTILE IRON PIPING
A. Cover underground ductile iron piping, including connecting galvanized steel spools, fittings, and like items with a loose, polyethylene plastic-film wrap to provide a continuous barrier between the pipe and the surrounding backfill.
1. Wrap in accordance with AWWA-C105.
2. Wrapping isolates the pipe surfaces from contact with corrosive environments, and is not intended to provide complete sealing or to prevent ground water intrusion.
B. Cut poly-wrap tube to a length approximately 2-feet (600-mm) longer than the length of the pipe section.
   1. Slip the poly-wrap around the pipe, centering it to provide a 1-foot (300-mm) overlap of each adjacent pipe section and bunching it accordion fashion until it clears the pipe ends.
   2. Lower the pipe into the trench and make-up the pipe joint with the preceding section of pipe. Make a shallow bell hole at joints to facilitate installation of the poly-wrap.

C. After completing the joint, make the overlap.
   1. Pull the bunched-up poly-wrap from the preceding length of pipe, slip it over the end of the new length of pipe, and secure it in place with two circumferential turns of tape plus enough overlap to assure firm adhesion.
   2. Slip the end of the poly-wrap from the new pipe section over the end of the first wrap until it overlaps the joint at the end of the preceding length of pipe.
   3. Tape it in place using three circumferential turns of tape. Take up the slack width to make a snug, but not tight, fit along the barrel of the pipe, securing the fold as necessary with adhesive tape at approximately 3-foot (900-mm) centers.

D. Repair any rips, punctures, or other damage to the poly-wrap with short length of poly-wrap tube cut open, wrapped around the pipe, and secured with tape.

E. Wrap the next section of pipe in the same manner.

F. Cover bends, reducers, and offsets with poly-wrap in the same manner as the pipe.

G. Wrap valves and other odd-shaped piece that cannot practically be wrapped in a tube, with a flat sheet obtained by splitting open a length of poly-wrap tube.
   1. Pass the flat sheet under the valve and bring it up around the body of the stem.
   2. Make the seams by bringing the edges together, folding over twice, and taping down. Slack width and overlaps at joints shall be handled as described above.
   3. Tape poly-wrap securely in place at valve stem and other penetrations.

H. Where poly-wrapped pipe joins a pipe that is not poly-wrapped, extend the poly-wrap tube to cover the unwrapped pipe a distance of 2 feet (600-mm), unless shown otherwise on the drawings. Secure the end with at least three circumferential turns of tape.

3.17 HYDROSTATIC PRESSURE AND LEAKAGE TEST

A. General:
   1. Provide all necessary materials and equipment, including water.
   2. Backfill all trenches sufficient to hold pipe firmly in position.
   3. Allow time for thrust blocks to cure prior to testing.
   4. Flush all pipes prior to testing to remove all foreign material.
   5. Perform pressure and leakage test concurrently.
   6. Test pressure: See Subsection titled "System Performance Requirements."
   7. Apply test pressure by means of a pump connected to the pipe.
   8. Base test pressure on the elevation of the lowest point in the line.
   9. Fill each closed valve section or bulk-headed section slowly. Expel air from section being tested by means of permanent air vents installed at high points or by means
of temporary corporation cocks installed at such points. Remove and plug the
temporary corporation cocks at the conclusion of the test.
10. Allow water to stand in the pipe for 24 hours before test pressure is applied.
11. Allow the system to stabilize at the test pressure before conducting the leakage
test.
12. Do not operate valves in either the opening or closing direction at differential
pressures above the valves rated pressure.
13. Maintain test pressure as specified for type of pipe being tested.
14. Pressure Test: Examine any exposed pipe, fittings, valves, hydrants and joints
during the test, if no leaks are observed the section of line has passed the pressure
test. If leaks are observed, repair any damaged or defective pipe, fittings, valves,
or hydrants, and repeat the pressure test.
15. Leakage Test: Perform as specified hereafter for the type of pipe being installed.

B. DIP Leakage Test: Perform in accordance with AWWA C600. Selected requirements
of AWWA C600 are repeated as follows:
1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. No piping will be accepted if the leakage is greater than that determined by the
following formula:

\[
L = \frac{(S \times D \times P^{1/2})}{133,200}
\]

\[L = \text{Allowable leakage, gallons per hour.}\]
\[S = \text{Length of pipe tested, feet.}\]
\[D = \text{Nominal diameter of pipe, inches.}\]
\[P = \text{Average test pressure during the leakage test, pounds per square inch\ (gauge).}\]

C. PE Pipe Leakage Test: [The following leakage test for PE water pipe was taken from
the Phillips Petroleum Company (Richardson, TX) (Tel. 800 527 0662) catalog for
“Driscopipe.”]
1. Apply the test pressure and allow the pipe to stand, without makeup pressure, for
sufficient time to allow for diametric expansion or pipe stretching to stabilize, approximately two to three hours.
2. After the above stabilization has occurred, return the section being tested to the
test pressure. Hold the test pressure for one to three hours. If the pressure in the
test section drops, and it is determined the drop may be the result of expansion
resulting from increasing temperature, a limited amount of additional water may be
added to bring the pressure back to the test pressure. Allowable amounts of make-
up water, to compensate for expansion due to increasing temperature, are as
shown in the following table. Make-up water is only allowed during this final test
period and not during the initial stabilization described in the previous paragraph.
If the additional water added is less than the allowable shown in the table and there
are no visual leaks or significant pressure drops, the tested section passes the
test.

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>Allowance for Expansion (U.S. Gals./100 Feet of Pipe)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-Hour 2-Hour 3-Hour</td>
</tr>
</tbody>
</table>

WATER DISTRIBUTION SYSTEM
D-4012 Diablo Valley College Physical Education and
Kinesiology Complex

33 11 66 - 15
<table>
<thead>
<tr>
<th>Test</th>
<th>Test</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.10</td>
<td>0.15</td>
</tr>
<tr>
<td>4</td>
<td>0.13</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>0.30</td>
<td>0.60</td>
</tr>
<tr>
<td>8</td>
<td>0.50</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>0.75</td>
<td>1.3</td>
</tr>
<tr>
<td>11</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>12</td>
<td>1.1</td>
<td>2.3</td>
</tr>
<tr>
<td>14</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>16</td>
<td>1.7</td>
<td>3.3</td>
</tr>
<tr>
<td>18</td>
<td>2.2</td>
<td>4.3</td>
</tr>
<tr>
<td>20</td>
<td>2.8</td>
<td>5.5</td>
</tr>
<tr>
<td>22</td>
<td>3.5</td>
<td>7.0</td>
</tr>
<tr>
<td>24</td>
<td>4.5</td>
<td>8.9</td>
</tr>
<tr>
<td>28</td>
<td>5.5</td>
<td>11.1</td>
</tr>
<tr>
<td>32</td>
<td>7.0</td>
<td>14.3</td>
</tr>
<tr>
<td>36</td>
<td>9.0</td>
<td>18.0</td>
</tr>
<tr>
<td>40</td>
<td>11.0</td>
<td>22.0</td>
</tr>
<tr>
<td>48</td>
<td>15.0</td>
<td>27.0</td>
</tr>
</tbody>
</table>

D. PVC Pipe Leakage Test: Perform in accordance with AWWA M23. Selected requirements of AWWA M23 are repeated as follows:
1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. No piping will be accepted if the leakage is greater than that determined by the following formula:

\[ L = \frac{(N \times D \times P^{1/2})}{7,400} \]

- \( L \) = Allowable leakage, gallons per hour.
- \( N \) = Number of joints in the length of the pipeline tested.
- \( D \) = Nominal diameter of pipe, inches.
- \( P \) = Average test pressure during the leakage test, pounds per square inch (gauge).

E. Cement Mortar Lined and Coated Steel Pipe Leakage Test: Perform in accordance with AWWA M11. Selected requirements of AWWA M11 are repeated as follows:
1. Maintain the test pressure, +/- 5 psi, for a minimum of two hours.
2. There shall be no significant leakage for pipe with welded joints or mechanical couplings.
3. For pipe joined with O-ring rubber gaskets, a leakage of 25 gallons per inch of diameter per mile per 24-hours is allowed.

3.18 DISINFECTION

A. All New Pipelines shall be disinfected in accordance with one of the three methods specified in AWWA C651 and the following:
1. Disinfect after pressure and leakage test have been performed and accepted.
2. The method used shall be at the Contractor’s option, unless specified by the owner of the water system.
3. Engage the services of a commercial testing laboratory, approved by the owner of the water system, to perform the bacteriological tests specified in Section 5.1 of AWWA C651. Direct the testing laboratory to send the original report of the
bacteriological testing to the owner of the water system. Should the laboratory report show that any sample taken was not acceptable, repeat the sterilization process shall until a satisfactory sterilization is accomplished.

4. Lawfully dispose of the chlorinated water.

END OF SECTION
SECTION 33 31 00
SANITARY SEWER SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Roadway and/or site sanitary gravity sewers and force mains up to 5 feet of any on-site building.

1.02 RELATED SECTIONS
   A. Section 31 23 33, Utility Trenching and Backfill
   B. Section 32 05 23, Portland Cement Concrete

1.03 RELATED DOCUMENTS
   A. AASHTO:
      1. M 199: Precast Reinforced Concrete Manhole Sections.
   B. ASTM:
      1. A 615/A615M: Deformed and Billet-Steel Bars for Concrete Reinforcement.
      2. A 674 Practice for Polyethylene Encasement for Ductile Iron Pipe for Water and Other Liquids.
      7. D 1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
     12. D 3034: Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
C. AWWA:
   3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water.

D. Caltrans Standard Specifications.
   1. Section 51, Concrete Structures.
   2. Section 65, Concrete Pipe
   3. Section 75 Miscellaneous Metal.

1.04 REGULATORY REQUIREMENTS

A. Central Contra Costa Sanitary District Standard Details and Specifications

1.05 DEFINITIONS

A. AASHTO: American Association of State Highway and Transportation Officials.
E. PVC: Polyvinyl Chloride.

NPS: Nominal pipe size.

1.06 SUBMITTALS

A. Submittal procedure shall be as outlined in Division 1 – General Requirements.

B. Product data for the following:
   1. Piping materials and fittings.
   2. Special pipe couplings.
   4. Cleanout plugs or caps.
   5. Sewage air relief valves.

C. Shop drawings: Include plans, elevations, details and attachments for the following:
   1. Precast concrete manholes, frames and covers.
   2. Precast concrete clean out boxes and box covers.
   3. Force main piping access openings.

D. Design Mix Reports and Calculations: For each class of cast in place concrete.
E. Field Test Reports: Indicate and interpret test results for compliance with performance.

1.07 DELIVERY, STORAGE AND HANDLING

A. Do not store plastic pipe and fittings in direct sunlight.

B. Protect pipe, fittings, and seals from dirt and damage.

C. Handle precast concrete pipe, manholes and other precast structures according to manufacturer’s written instructions.

D. Protect imported bedding and backfill material from contamination by other materials.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS FOR GRAVITY FLOW

A. PVC Pipe:
   1. Pipe:
   2. Fittings:
      a. 4-inch through 27-inch: ASTM F 1336.

2.02 GRAVITY PIPE CLEANOUTS

A. Piping: Same as sanitary sewer line if possible.

B. Top Cap: Threaded and of same material as piping if possible.

C. Box Size: As required to provide access and allow easy removal and reinstallation of cap.

D. Box Types:
   2. Traffic Areas: Portland cement concrete box and box cover or steel or cast iron cover, heavy duty, both box and cover to be rated for AASHTO H20 loading.

E. Box Cover Markings: “S.S.,” unless otherwise specified.

F. Available Manufacturers: Subject to compliance with requirements, box manufacturers offering products that may be incorporated into the Project include, but are not limited to the following:
   1. Associated Concrete Products, Inc. (Santa Ana, California) (Tel. 714-557-7470).
   2. Brooks Products Inc. (El Monte, California) (Tel. 818-443-3017).
   3. Christy Concrete Products, Inc. (Fremont, California) (Tel. 800-486 7070).

2.03 MANHOLES

A. General: Size, shape, configuration, depth, etc. of manhole and frame and cover shall be as indicated.
B. Portland Cement Concrete and Reinforcing:
   1. Poured-in-Place Portion: Section 32 05 23.
   2. Precast Portion: ASTM C 478. Rate for AASHTO H20 loading in traffic areas.

C. Frames and Covers: As indicated and in accordance with Caltrans Standard Specification Section 75-1.02B.

D. Steps: Manufacture from deformed, 1/2-inch steel reinforcement rod complying with ASTM A 615/A 615M and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step. Acceptable manufacturer is Hanson Concrete Products, (Milpitas, CA) (Tel 408-262-1091) or equal.

E. Force Main Piping Access Openings:
   1. General: As indicated.

2.04 JOINT SEALANT FOR STRUCTURES AND MANHOLES

A. Mortar: Caltrans Standard Specification Section 51-1.03E.
   1. Use to seal around pipes at connections to structures and manholes. Also use to seal joints between precast sections of structures and manholes.

B. Gaskets: Preformed flexible rubber or plastic gasket.
   2. Plastic Gaskets: Federal Specification SS-S-00210 (GSA-FSS), Type I, Rope Form; or alternate standard which may exist. Acceptable material is “Ram-Nek,” as manufactured by the K. T. Snyder Company (Houston TX), or approved equal.

PART 3 - EXECUTION

3.01 GRAVITY PIPE INSTALLATION

A. General: Install pipe, fittings, and appurtenances utilizing best practices, manufacturer’s instructions, and in accordance with Section 6 and 7 of ASTM D 2321 for plastic pipe, Caltrans Standard Specification Section 65-2 for reinforced concrete pipe and chapter 11.3.3 of AWWA M41 for ductile iron pipe.

B. Pipe Depth and Trench Configuration: Conform to typical trench section(s) indicated.

C. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33.

D. Handling: Carefully handle during loading, hauling, unloading and placing operations to avoid breakage or damage. Use strap type slings for lifting and placing; no chains or hooks will be permitted. Comply with the manufacturer’s recommendations.

E. Laying: Before lowering pipe into the trench, remove all stakes, debris, loose rock and other hard materials from the bottom of the trench. Lay accurately in conformance with lines and grades indicated. Start laying the pipeline at the low end and proceed upstream. Lay bell and spigot pipe with the bell end facing upstream. Lay pipe on a bed prepared by handwork, dug true to grade. Furnish firm bearing for pipe throughout its entire length with bell holes provided at the ends of each pipe length of sufficient size to permit making up the particular type of joint being used. Adjust pipe to line and grade.
by scraping away or filling and tamping material under the body of the pipe for the entire pipe length and not by blocking or wedging. After final positioning, hold pipe in place in trench with backfill material placed equally on both sides of the pipe at as many locations as required to hold the pipe section in place.

F. Curved Alignment: When necessary to conform to the alignment specifically indicated, lay pipe on a curved alignment by means of asymmetrical closure of joints or bending of the pipe barrel. Use shorter lengths of pipe than the standard length if necessary to achieve curvature specified. Do not exceed the recommendations of the pipe manufacture for deflections at the joints or pipe bending.

G. Closure: Close open ends of pipes and appurtenance at the end of each day’s work or when work is not in progress.

3.02 SPECIAL PIPE COUPLINGS

A. General: Use where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

B. Installation: Manufacturer’s instructions.

3.03 CLEANOUT INSTALLATION

A. General: Install as indicated.

3.04 MANHOLE INSTALLATION

A. General: Install as indicated.

3.05 TESTING OF GRAVITY PIPING MAINS

A. Obstructions: After backfilling and compacting, but before paving or other surface improvements, test sewer for obstructions either by rodding or by the sewer ball method. Provide for intercepting all grit, rocks and other flushed debris to keep debris from entering the existing system.

B. At the option of the Contractor, either the following hydrostatic or air test shall be performed.

C. Hydrostatic Test:
   1. Test after backfilling to finish grade or pavement structural section subgrade in paved areas.
   2. Test sewer mains between successive manholes by closing the lower end of the sewer main to be tested and the inlet sewer main of the upper manhole with stoppers.
   3. Fill pipe and manholes with water to a point four feet below the ground surface of the upper manhole, but in no case less than four feet above the pipe invert. If ground water is present, the water surface at the upper manhole shall be at least four feet above the level of the ground water.
   4. Fill piping at least one hour prior to testing.
5. Test piping at least two hours by maintaining the head specified above with measured additions of water. The sum of these additions of water, in the two-hour test period, shall be the leakage amount.

6. The maximum allowable head of water above any portion of sewer being tested shall be 15-feet. Where the difference in elevation between successive manholes exceeds 15-feet, a test tee shall be installed between manholes, and the testing shall be carried on between the tee and the manhole.

7. The allowable leakage shall not exceed 0.1-gallons per minute per inch diameter, per 1000-feet of sewer main being tested.

8. If the leakage exceeds the above amount, determine the cause and remedy it prior to retesting.

9. If the leakage is less than the allowable, but leaks are observed, repair the observed leaks.

D. Air Test:
1. Test after backfilling to finish grade or pavement structural section subgrade in paved areas.

2. Apply to each length between adjacent manholes.

3. Supply pressure gauge with minimum divisions of 0.10-psi and with an accuracy of +/- 0.04-psi. When requested by the Owner’s Representative, provide certification that the gauge has been tested for accuracy within the last six months by a reliable testing firm.

4. Pressurize the test section to 3.5-psi, and then hold the pressure above 3.0-psi during a saturation period of at least 5 minutes. At the end of the saturation period, note the pressure, which must be a minimum of 3.0-psi, and begin the timed period. If the pressure drops 0.5-psi in less than the time given in the following table the section of pipe has not passed the test.

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Minimum Time Allowed for Pressure to Drop 0.5-PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4”</td>
<td>125 seconds</td>
</tr>
<tr>
<td>6”</td>
<td>185 seconds</td>
</tr>
<tr>
<td>8”</td>
<td>245 seconds</td>
</tr>
<tr>
<td>10”</td>
<td>310 seconds</td>
</tr>
<tr>
<td>12”</td>
<td>370 seconds</td>
</tr>
<tr>
<td>15”</td>
<td>460 seconds</td>
</tr>
<tr>
<td>18”</td>
<td>555 seconds</td>
</tr>
<tr>
<td>21”</td>
<td>10 minutes</td>
</tr>
<tr>
<td>24”</td>
<td>12 minutes</td>
</tr>
</tbody>
</table>

5. If the time for the pressure to drop 0.5-psi is 125% or less of the time indicated, the line shall immediately be re-pressurized to 3.0-psi and the test repeated. If, during the 5-minute saturation period, the pressure drops less than 0.5-psi after the initial pressurization and air is not added, the section undergoing the test shall have passed.
6. If the test did not pass, find and repair the leak to the satisfaction of the Owner’s Representative.

7. When the prevailing ground water is above the line being tested the air pressure shall be increased 0.43-psi for each foot the water table is above the invert of the pipe at the highest manhole.

3.06 TESTING OF LATERALS

A. At the option of the Contractor, either the following hydrostatic or air test shall be performed.

B. Hydrostatic Test:
   1. Test laterals before backfilling.
   2. Plug lateral at its ends and fill with water through the cleanouts.
   3. Maintain the water level in the cleanouts as high as possible throughout the test period.
   4. One hour after filling with water, examine the lateral for leakage.
   5. Repair all leaks to the satisfaction of the Owner’s Representative.
   6. Do not backfill the trench until testing and repairs of the lateral are complete, and approved by the Owner’s Representative.
   7. Following approval of the Owner’s Representative, remove all plugs, dispose of the water and complete the connection to the main.

C. Air Test
   1. Test after backfilling to finish grade or pavement structural section subgrade in paved areas.
   2. Test in accordance with subsection above titled “Testing of Gravity Piping Mains,” paragraph titled “Air Test.”

3.07 TESTING OF MANHOLES ON GRAVITY LINES

A. At the option of the Contractor, either the following hydrostatic or vacuum test shall be performed.

B. Hydrostatic Test:
   1. Insert inflatable plugs in all sewer inlets and outlets.
   2. Fill the manhole with water to a point six inches below the base of the manhole frame.
   3. Maintain the water at this point for one hour to allow time for absorption.
   4. Begin one-hour test period. Measure the amount of water added in one-hour period to maintain the water level at six inches below the base of the manhole frame. Do not allow water level to drop more than 25% of the manhole depth.
   5. Determine the allowable leakage by the following formula.

\[ L = 0.0002 \times D \times H^{1/2} \]

\( L \) = Allowable leakage, gallons per minute.
\( D \) = Depth of manhole from top to bottom, feet.
\( H \) = Head of water in feet as measured from the surface of the water in the manhole to the sewer line invert or to the prevailing ground water surface outside the manhole. The lesser height governs.
6. If the leakage exceeds the allowable, determine the cause, take remedial action and re-test the manhole. If the leakage is less than the allowable and leaks are observed, repair the leaks.

C. Vacuum Test:
1. General: Test in accordance with ASTM C 1244.
2. Test prior to backfilling around the manhole.
3. Test Preparation: Plug all lift holes and pipes entering or exiting the manhole.
4. Place test head inside the top section of the manhole’s cone section and inflate in accordance with the manufacturers instructions.
5. Draw a vacuum of 10-inches of mercury and shut the pump off.
6. With the valve closed, the time for the vacuum to drop 9-inches shall be measured.
7. The manhole shall pass the test if the time is greater than 60 seconds for a 48-inch diameter manhole, 75 seconds for a 60-inch diameter manhole and 90 seconds for a 72-inch diameter manhole.
8. If the manhole fails the initial test, make necessary repairs with a non-shrink grout while the vacuum is still being drawn. Retest until a satisfactory test is obtained.

END OF SECTION
SECTION 33 41 00
STORM DRAINAGE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Provide and install all appurtenances as necessary to complete the storm drainage system and bioretention system, as shown on the plans, including piping and joints, flexible joints, manholes, catch basins, drain inlets, and area drains.

1.02 RELATED SECTIONS

A. Section 31 23 33– Utility Trenching and Backfill
B. Section 32 05 23, Portland Cement Concrete
C. Section 33 46 00 - Subdrainage

1.03 RELATED DOCUMENTS:

A. AASHTO:
   1. M 199: Precast Reinforced Concrete Manhole Sections.

B. ASTM:
   1. A615/A615M: Deformed and Billet-Steel Bars for Concrete Reinforcement.
   2. C 443: Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
   6. D 1785: Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   10. F 477: Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

C. AWWA:
   3. C110: Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (76 mm Through 1,219 mm) for Water.

D. Caltrans Standard Specifications
   1. Section 52 Reinforcement
   2. Section 65 Reinforced Concrete Pipe

1.04 REGULATORY REQUIREMENTS:
   A. City of Pleasant Hill, Standard Specifications and Details.
   B. Central Contra Costa Sanitary District, Standard Specifications and Details.

1.05 DEFINITIONS
   A. AASHTO: American Association of State Highway and Transportation Officials.
   D. HDPE: High-density polyethylene.
   E. NPS: Nominal pipe size.
   F. PVC: Polyvinyl chloride.
   G. RCP: Reinforced concrete pipe.

1.06 SUBMITTALS
   A. Submittal procedure shall be as outlined in Division 1 – General Requirements.
   B. Product Data Shop Drawings, etc. for the following:
      1. Piping materials and fittings.
      2. Special pipe couplings.
      4. Plastic area drains.
      5. Cleanout plugs or caps.
      6. Precast manholes
      7. Precast concrete catch basins, inlets, curb inlets, junction structures and area drains, including frames and grates.
      8. Precast clean out boxes and box covers.
      9. Bio-retention soil
   C. Design Mix Reports and Calculations: For each class of cast in place concrete.
   D. Field Test Reports: Indicate and interpret test results for compliance with performance.
1.07 DELIVERY, STORAGE AND HANDLING

A. Do not store plastic structures, pipe and fittings in direct sunlight.

B. Protect pipe, fittings, and seals from dirt and damage.

C. Handle precast concrete pipe, manholes and other precast structures according to manufacturer’s written instructions.

D. Protect imported bedding and backfill material from contamination by other materials.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS FOR GRAVITY FLOW

A. PVC Pipe and Fittings: Pipes 12” and smaller in diameter shall be SDR 26 PVC conforming to ASTM D3034 using elastomeric gasket joint in a bell and spigot assembly system or as shown on plans. Minimum 2 feet cover, maximum 15 feet cover.
   1. Fittings: Shall conform to ASTM F 1336.

B. Reinforced Concrete Pipe: Pipes greater than 12” in diameter shall be Class III, Type II Portland Cement conforming to ASTM C76 and C150 or as shown on plans.

C. HDPE Pipe and Fittings: (As alternate to PVC only) pipes can be HDPE (High Density Polyethylene Pipe) DR-11 (160 psi), conforming to ASTM F714 and AASHTO designation M-294.

D. Manholes
   1. General:
      a. Size, shape, configuration, depth, etc. of manhole and frame and cover shall be as indicated.
   2. Portland Cement Concrete and Reinforcing:
      a. Poured-in-Place Portion: Section 03 30 00 – Portland Cement Concrete.
      b. Precast Portion:
         1) Pre-cast Concrete manhole conforming to ASTM C478 and shall be Type II modified cement with a minimum compressive strength of 4,000 psi at 28 days. Iron Castings for manhole covers and frames shall conform to ASTM A48, Class 25
         2) ASTM C 478. Rate for AASHTO H20 loading in traffic areas.
   3. Frames and Covers: As indicated and in accordance with Caltrans Standard Specification Section 75-1.02.
   4. Steps: Manufacture from deformed, ½-inch steel reinforcement rod complying with ASTM A 615/A 615M and encased in polypropylene complying with ASTM D 4101. Include pattern designed to prevent lateral slippage off step.
      a. Acceptable manufacturers include:
         1) Hanson Concrete Products, (Milpitas, CA) (Tel 408-262-1091)
         2) Or approved equal.

E. Concrete Trench Drains
1. Modular system of concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include number of units required to form total length required.

2. Include the following components:
   a. Channel Sections: Interlocking-joint, precast modular units with end caps. Inside width as indicated with deep, rounded bottom, with built in slope or flat invert as indicated and outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
   b. Frame and Grate: Ductile iron as indicated. Where drain is located in traffic areas, rate for AASHTO H20 loading.

3. Locking Mechanism: Manufacturer’s standard device for securing grates to channel sections.

4. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
   a. “Polydrain” by ABT Inc. (Troutman, NC) (Tel 704-528-9806).
   b. “ACO Drain” by ACO Polymer Products Inc. (Chardon, OH) (Tel. 800-543-4764).
   c. Or approved equal.

F. Cleanouts
   1. Piping: Same as storm drain line if possible.
   2. Top Plug or Cap: Same material as piping if possible. Plug or cap to be secure but removable, threaded or non-threaded.
   3. Box Size: As required to provide access and allow easy removal and reinstallation of plug or cap.
   4. Box Types:
      b. Traffic Areas: Portland cement concrete box and box cover or steel or cast iron cover, heavy duty, both box and cover to be rated for AASHTO H20 loading.
   6. Available Manufacturers: Subject to compliance with requirements, box manufacturers offering products that may be incorporated into the Project include, but are not limited to, the following:
      a. Associated Concrete Products, Inc. (Santa Ana, California) (Tel. 714-557-7470).
      b. Brooks Products Inc. (El Monte, California) (Tel. 818-443-3017).
      c. Christy Concrete Products, Inc. (Fremont, California) (Tel. 800-486-7070).

G. Area drains shall only be used on 6 inch in diameter or smaller storm drain lines.
   1. Area drains shall be polyvinyl chloride.
   2. Grates shall be brass and comply with accessibility requirements.
   3. Rate for AASHTO H20 loading in traffic areas.

H. Catch Basins shall be pre-cast or cast-in-place with 3,000 psi concrete and 1-1/2 inch max aggregate size.

I. Frames, Grates and Covers for Catch Basins: Caltrans Standard Specification Section 75-1.02, 75-1.03 and 75-1.05.
1. Galvanize steel frames, grates and covers.
2. Grates and covers shall be non-rocking.
3. Rate for AASHTO H20 loading in traffic areas.

2.02 SPECIAL PIPE COUPLINGS
1. Gravity Piping: ASTM C 1173. Rubber or elastomeric sleeve and band assembly fabricated to match outside diameters of pipes to be joined.

2.03 JOINT SEALANT FOR PRECAST STRUCTURES AND MANHOLES
   1. Use to seal around pipes at connections to structures and manholes. Also use to seal joints between precast sections of structures and manholes.

B. Gaskets: Preformed flexible rubber or plastic gasket.
   2. Plastic Gaskets: Federal Specification SS-S-00210 (GSA-FSS), Type I, Rope Form; or alternate standard which may exist.

PART 3 - EXECUTION

3.01 GRAVITY PIPE INSTALLATION
A. Construct all storm drainage utilities to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations.

B. Install pipe, fittings, and appurtenances utilizing best practices, manufacturer’s instructions, and in accordance with Section 6 and 7 of ASTM D 2321 for plastic pipe, Caltrans Standard Specification Section 65-1.07 for reinforced concrete pipe, and chapter 11.3.3 of AWWA M41 for cast iron and ductile iron pipe.

C. Pipe Depth and Trench Configuration: Conform to typical trench section(s) indicated.

D. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill

E. Handling: Carefully handle during loading, hauling, unloading and placing operations to avoid breakage or damage. Use strap type slings for lifting and placing; no chains or hooks will be permitted. Comply with manufacturer’s recommendations.

F. Laying: Before lowering pipe into the trench, remove all stakes, debris, loose rock and other hard materials from the bottom of the trench. Lay accurately in conformance with lines and grades indicated. Start laying the pipeline at the low end and proceed upstream. Lay bell and spigot pipe with the bell end facing upstream. Lay pipe on a bed prepared by handwork, dug true to grade. Furnish firm bearing for pipe throughout its entire length with bell holes provided at the ends of each pipe length of sufficient size to permit making up the particular type of joint being used. Adjust pipe to line and grade by scraping away or filling and tamping material under the body of the pipe for the entire pipe length and not by blocking or wedging. After final positioning, hold pipe in place in
trench with backfill material placed equally on both sides of the pipe at as many locations as required to hold the pipe section in place.

G. Curved Alignment: When necessary to conform to the alignment specifically indicated, lay pipe on a curved alignment by means of asymmetrical closure of joints or bending of the pipe barrel. Use shorter lengths of pipe than the standard length if necessary to achieve curvature specified. Do not exceed the recommendations of the pipe manufacture for deflections at the joints or pipe bending.

H. Closure: Close open ends of pipes and appurtenance openings at the end of each days work or when work is not in progress.

3.02 SPECIAL PIPE COUPLINGS

A. General: Use where required to join piping and no other appropriate method is specified. Do not use instead of specified joining methods.

B. Installation: Manufacturers’ instructions.

3.03 CLEANOUT INSTALLATION

A. General: Install as indicated.

3.04 INSTALLATION OF CURB INLETS, CATCH BASINS, DROP INLETS, JUNCTION STRUCTURES, AREA DRAINS, ETC. AND MANHOLES

A. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill

B. Poured in Place Structures: Install as indicated and Caltrans Standard Specification Section 51.
   1. Shape bottoms to convey flows as indicated.

C. Precast Structures: Install as indicated.
   1. Seal all joints and pipe entrances and exits.
   2. Place concrete in bottom and shape to convey flows as indicated.

3.05 CONCRETE TRENCH DRAIN INSTALLATION

A. Excavation, Bedding, Backfill, and Compaction: Section 31 23 33 – Utility Trenching and Backfill

B. Install: As indicated and in accordance with the manufacturer’s instructions.

C. Valve shall be installed in accordance with manufacturers’ written Installation and Operation Manual and approved submittals.

3.06 TRENCHING AND EXCAVATION

A. Existing PCC or AC Areas: Cut PCC or AC to full depth at a minimum distance of 12-inches beyond the edge of the trench.
B. Excavate by hand or machine. For gravity systems begin excavation at the outlet end and proceed upstream. Excavate sides of the trench parallel and equal distant from the centerline of the pipe. Hand trim excavation. Remove loose matter.

C. Excavation Depth for Bedding: Minimum of 4-inches below bottom of pipe or as otherwise allowed or required by the District’s Representative, except that bedding is not required for nominal pipe diameters of 2-inches or less.

D. Excavation Width at Springline of Pipe:
1. Up to a nominal pipe diameter of 24-inches: Minimum of twice the outside pipe diameter, or as otherwise allowed or required by the District.
2. Nominal pipe diameter of 30-inches through 36-inches: Minimum of the outside pipe diameter plus 2-feet, or as otherwise allowed or required by the District.
3. Nominal pipe diameter of 42-inches through 60-inches: Minimum of the outside pipe diameter plus 3-feet, or as otherwise allowed or required by the District.

E. Over-Excavations: Backfill trenches that have been excavated below bedding design subgrade, with approved bedding material.

F. Comply with the District limitations on the amount of trench that is opened or partially opened at any one time. Do not leave trenches open overnight without the approval of the District.

G. Where forming is required, excavate only as much material as necessary to permit placing and removal of forms.

H. Bottoms of trenches will be subject to testing by District. Correct deficiencies as directed by the District.

I. Grade bottom of trench to provide uniform thickness of bedding material and to provide uniform bearing and support for pipe along entire length. Remove stones to avoid point bearing.

3.07 BACKFILLING
A. Backfill per Section 31 23 33: Utility Trenching and Backfill.

3.08 CLEANUP
A. Upon completion of utility earthwork all lines, manholes catch basins, inlets, water meter boxes and other structures shall be thoroughly cleaned of dirt, rubbish, debris and obstructions of any kind to the satisfaction of the District.

3.09 TESTING
A. General: Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours advance notice.
4. Submit separate reports for each test.
5. Where authorities having jurisdiction do not have published procedures, perform tests in accordance with latest edition of the Uniform Plumbing Code (UPC) Section 1109.0, Testing.
6. Leaks and loss in test pressure constitute defects that must be repaired.
7. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

B. Storm Drain Pipe:
1. Storm drain pipe, shall be hydrostatically joint tested, (air test is not to be used), in the field for water-tightness in accordance with ASTM Standard C 1103.
2. Perform test after pipe is bedded but prior to any backfill.
3. Testing may be done by manufacturing pipe with double gasket joints, or by utilizing a joint tester. Contractor shall obtain the District’s Representative’s approval of details of the Contractor’s selected method prior to performing the testing.
4. Inspect all joints for leakage.
5. If the pressure holds, or drops less than 1psi in 5 seconds, the joint is acceptable.
6. After backfill of storm drain, the Contractor shall video inspect the pipeline. The video shall be supplied to the District for review.

3.10 DISPOSAL
A. Lawfully dispose of all unsuitable and excess or surplus material off-site at no cost to the District.

3.11 CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL
A. Construction Waste shall be managed in accordance with provisions of Standard Construction Waste Management and Disposal Practices. Documentation shall be submitted to satisfy the requirements of that section.

END OF SECTION