ADDENDUM #3

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

D-4002 San Ramon Campus Expansion and Renovation Increment 1
Diablo Valley College San Ramon Campus
1690 Watermill Road, San Ramon, CA 94582

Date: 12/14/2018

NOTICE TO ALL CONTRACTORS:
You are hereby notified of the following changes, clarifications and/or modifications to the original Contract Documents, Project Manual, Drawings, Specifications and/or previous Addenda. This Addendum shall supersede the original Contract Documents and previous Addenda wherein it contradicts the same and shall take precedence over anything to the contrary therein. All other conditions remain unchanged.

This Addendum forms a part of the Contract Documents and modifies the original Contract Documents dated October 25, 2018. Acknowledgement of receipt of this addendum in the space provided in the Bid Proposal Form. Failure to acknowledge may subject proposer to disqualification.

A. Deletions, Additions, Changes, Revisions

Item:

1. **Additions**
   a. As an exhibit for Specification Section 00300 a sample Bid Bond Form is provided.
   b. Drawings: Not Applicable
2. **Deletions:**
   a. Drawings: Not Applicable
3. **Revisions:**
   a. Drawings: Replace the following project drawing sheets in their entirety, note clouded revisions:
      i. A0.01.0 - Note Symbols Legend delta revision symbol.
      ii. A2.36.1 - Note revisions to drawing numbers, 1, 2, 3, 4, 5, & Key Notes.
      iii. A2.37.1 - Note revisions to Key Notes & drawing number 2 addition of detail reference.
      iv. A8.10.1 - Note deletion of partition types H & J
      v. A8.11.1 - Note addition of detail 8. Note deletion of details 5 & 10. Note clarification of structure in details 3 & 9
      vi. A8.13.1 - Note addition of detail 4.
      vii. A8.21.1 - Note revision of detail 4, clarification of detail 10, addition of detail 13.
      viii. A8.73.1 - Note clarification of detail 4.

    ix. A9.13.1 - Note addition of Schedule of Interior Finishes.

    x. Q0.02.1 - Note clarification of safety glazing at wood laboratory casework & cabinet designation clarifications.

    xi. Q2.37.1 – Note revision to key notes & clarification of OFOI equipment.

    xii. Q7.11.1 - Note addition of detail reference, drawing 5 elevation 6. Note clarification of cabinet designations on details; 2, 3, & 5. Note addition of clarifying keynotes

    xiii. E0.01.1 – Revised sheet index on sheet E0.01 to include sheet E2.38.1

    xiv. M2.38.1 – Revised sheet with added exhaust air by-pass duct to exhaust system and added housekeeping pad to new equipment in scope.

    xv. M6.01 -Added Lab exhaust control diagram.

b. Drawings: Note revisions on following sheets:

    i. A8.50.1 - Revise detail title of 6/A8.50.1 to read "Existing Exterior Window – Type 3".

    ii. A8.40.1- Add Door General note 11 to read "Exterior and interior door with window lite shall receive tempered glass".

    iii. S7.01.1 - Revise details 3 & 4, revise dimension for (N)W8x10 from edge of opening to center of beam from 6" to 8"

c. Specifications: The following project specification sections are amended as follows:

    i. <u>Specification Section 06 41 10 Custom Casework</u>

        1. Under 2.1 Materials

            a. Revise section E. Wood Veneer Slatwall Panels: Slatwall Systems, Inc or accepted equal. Slatwall panels consisting of grooved, veneer faced, medium-density fiberboard or plywood with aluminum inserts, ready to accept slatwall hangers and display units. Grooves 3" oc.

                i. Wood Species and Veneer Cut: White Maple

                ii. Staining and Finish: Transparent finish, Stain and matching adjacent casework may be required. TBD.

            b. Revise section F. Add text in section for F to clarify Glass and Glazing: Tempered Float Glass for Non-Laboratory Cabinet Doors Type 2 - ASTM C 1048, Kind FT, Condition A, Type I, Class I (clear), Quality Q3, thickness as required based on size of glazing unit.

            c. Revise section I. Hardware General Requirements.

                i. Revise the section 3a. and 3b as follows:

                    1. Drawer/Door Pulls: Round top drawer pull, 6 – 11/16", satin nickel finish, as manufactured by Doug Mockett & Company, DP128-17S, or equal

                    2. Hinges: Frameless concealed hinges (European type): BHMA A156.9, B01602, 170 degrees of opening, self-closing

            d. Add section for J. Millwork Trim at Bookstore Island Counter and Service

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Desk. Extruded aluminum profiles (reveals, channel, reveal angle, inside corner, outside corner, reveal base, corner keys): Aluminum alloy 6063T5 with clear anodized finish or from selection of standard integral anodized finishes, as manufactured by Fry Reglet Corp, or equal. Where indicated on drawings. Installs with ½", ¾" or 1" millwork panels.

    ii. <u>Specification Section 09 67 23 Resinous Flooring</u>
        1. Epoxy flooring is replaced by MMA flooring. Replace this specification section in its entirety with the attached revised section dated 12/14/18

    iii. <u>Specification Section 12 35 53 Laboratory Casework</u>
        1. Under 2.3 Wood Laboratory Casework and Fixed Benches
            a. Add section D. Glass: Where glazed cabinets are indicated, provide laminated tempered safety glass nominal 7/32-inch on framed glass doors. Provide glass without imperfections or marred surfaces. Provide identifying safety glass "bug" as a permanent part of the glass.
    iv. <u>Specification Section 23 09 00 Instrumentation and Control Performance Specifications</u>
        1. Replace this specification section in its entirety with revised dated 12/13/2018

B. **Responses to Requests for Information**
    a. Not Applicable.

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If you have any questions regarding this Addendum, please contact:

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END OF ADDENDUM #3

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BID BOND

KNOW ALL MEN BY THESE PRESENTS that we, the undersigned, (hereafter called "Principal"),   and _____
_____ (hereafter called "Surety"), are hereby held and firmly bound unto CONTRA COSTA COMMUNITY COLLEGE DISTRICT (hereafter called "Owner") in the sum of _____ ($_____) for the payment of which, well and truly to be made, we hereby jointly and severally bind ourselves, successors, and assigns.

SIGNED this _____ day of _____, 20____

The condition of the above obligation is such that whereas the Principal has submitted to the Owner a certain Bid, attached hereto and hereby made a part hereof, to enter into a contract in writing for the construction of _____.

NOW, THEREFORE,

a.   If said Bid is rejected, or

b.   If said Bid is accepted and the Principal executes and delivers a contract or the attached Agreement form within five (5) calendar days after acceptance (properly completed in accordance with said Bid), and furnishes bonds for his faithful performance of said Contract and for payment of all persons performing labor or furnishing materials in connection therewith,

Then this obligation shall be void; otherwise, the same shall remain in force and effect.

Surety, for value received, hereby stipulates and agrees that no change, extension of time, alteration, or addition to the terms of the contract, or the call for bids, or the work to be performed thereunder, or the specifications accompanying the same, shall in anyway affect its obligation under this bond, and it does hereby waive notice of any such change, extension of time, alteration, or addition to the terms of said contract, or the call for bids, or the work, or to the specifications.

In the event suit is brought upon this bond by the DISTRICT and judgment is recovered, the Surety shall pay all costs incurred by the DISTRICT in such suit, including without limitation, attorneys' fees to be fixed by the court.

IN WITNESS WHEREOF, Principal and Surety have hereunto set their hands and seals, and such of them as are corporations have caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, on the day and year first set forth above.

PRINCIPAL: _____

_____

ATTEST: (if individual, two witnesses are required)

By:_____   By:_____

Title:_____   Title:_____

ATTEST: (if corporation)

By:_____

Title:_____
    (Corporate Seal)

SURETY: _____

_____

ATTEST: (if individual, two witnesses are required)

By:_____   By:_____

Title:_____   Title:_____

ATTEST: (if corporation)

By:_____

Title:_____
    (Corporate Seal)

IMPORTANT:

       Surety companies executing bonds must possess a certificate of authority from the California Insurance Commissioner authorizing them to write surety insurance defined in California Insurance Code Section 105, and if the work or project is financed, in whole or in part, with federal, grant, or loan funds, it must also appear on the Treasury Department's most current list (Circular 570 as amended).

THIS IS A REQUIRED FORM.

Any claims under this bond may be addressed to:

(Name and Address of Surety)

_____

_____

_____

(Name and Address of agent or representative for
service of process in California if different from above)

_____

_____

_____

(Telephone Number of Surety and agent or
representative for service of process in California)

_____

_____

_____

Contra Costa Community College District   Section 00300 - Exhibit
Diablo Valley College   Bid Bond Form
D-4002 SRC Increment 1 - Renovation

SECTION 09 67 23

RESINOUS FLOORING

PART 1 - GENERAL

1.1   SUMMARY

A.   Section Includes: Resinous flooring and integral cove base, RE-1.

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

C.   Related Section
       1.   Section 09 97 25 - Vapor Emission Treatment Systems: Provision of vapor emission treatment system, as required.

1.2   REFERENCES

A.   ASTM - American Society for Testing and Materials
       1.   C109 - Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens).
       1.   ~~C307 - Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts and Monolithic Surfacings.~~
       2.   ~~C579 - Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts and Monolithic Surfaces.~~
       3.   ~~C580 - Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts and Monolithic Surfacings.~~
       2.   D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
       3.   D570 - Standard Test Method for Water Absorption of Plastics.
       4.   D638 - Standard Test Method for Tensile Properties of Plastics.
       4.   ~~D1044 - Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion.~~
       5.   ~~D2240 - Standard Test Method for Rubber Property - Durometer Hardness.~~
       ~~6~~5.   F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

1.3   SYSTEM DESCRIPTION

A.   Design Requirements: Provide slip retardant, tough-wearing, high impact, chemical- and abrasion-resistant coating with integral coved base over concrete surface.

1.4   SUBMITTALS

A.   Product Data: Submit manufacturer's data describing products.

B.   Samples
       1.   Submit line of colors and surface textures for review and selection.
       2.   Submit 12-inch by 12-inch panels of color and texture selected.

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C. Quality Control Submittals
1. Certificates: Submit letter from manufacturer certifying acceptability of installer.
2. Manufacturer's Instructions: Submit manufacturer's application instructions.

D. Contract Closeout Submittals: Submit maintenance instructions for care of flooring.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Endorsement by materials manufacturer and evidence of 3 years minimum experience in satisfactory installation of this type of flooring.

1.6 DELIVERY, STORAGE AND PROTECTION

A. Packing and Shipping: Deliver components to site in factory sealed, marked containers with batch numbers and dates of manufacturer clearly visible.

B. Storage and Protection: Store in area protected from weather and kept at temperatures within range recommended by manufacturer.

1.7 PROJECT CONDITIONS

A. Environmental Requirements
1. Arrange means of modifying and controlling air temperature and ventilation to provide optimum condition for application of work.
2. Provide barriers and other controls to restrict work areas during application and curing periods.

1.8 WARRANTY

A. Provide manufacturer's standard warranty covering failures in material and workmanship.
1. Warranty Period: 1 year from date of Substantial Completion.

B. Warranty shall not deprive the District of other rights the District may have under other provisions of the Contract Documents and will be in addition to and run concurrent with other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: ~~Stonhard;~~ BASF **Corporation, "MasterTop 1851 SRS CF Methyl Methacrylate (MMA) Acrylic Resin System"**; ~~Silikal America~~ **The Sherwin-Williams Company General Polymers Brand, "Bio-Flake Decorative Flooring System"; Sika Corporation, "Sikafloor Pronto MMA Flake System"**, or equal.

2.2 MATERIALS

A. Flooring with Integral Coved Base, RE-1**: Multiple component reactive resin MMA (methyl methacrylate) seamless flooring system with decorative flake finish that is chemical-resistant; minimum 1/8-inch thick.**

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1. ~~Troweled jointless flooring of 2 component epoxy resin formulation incorporating chemical resistant aggregates to a thickness of 1/4-inch.~~

1. **Resin System Components**
    a. **Saturating Primer/Sealer Coat: As manufactured by BASF Corporation, "MasterTop SRS 41P", or equal.**
    b. **Coving (if required): With appropriate filler, as manufactured by BASF Corporation, "MasterTop SRS 61BC Self-Leveling", or equal.**
    c. **Patching/Sloping (if required): As manufactured by BASF Corporation, "MasterTop 1817 SRS PC Polymer Concrete", or equal.**
    d. **Topping: As manufactured by BASF Corporation, "MASTERTOP SRS 61BC Self-Leveling", consisting of "MasterTop SRS 61BC Self-Leveling Resin" and "MasterTop SRS 100SL with Colored Flake Broadcast", or equal.**
        1) **Color of Flake: As selected by the Architect.**
    e. **Topcoat: As manufactured by BASF Corporation, "MasterTop SRS 71TC Colorless Topcoat Resin", or equal.**
        1) **Pigment: Color to compliment colored flake as selected by the Architect.**

2. Physical Characteristics
    a. ~~Compressive Strength: 11,000 psi in accordance with ASTM C579.~~
    b. ~~Tensile Strength: 1,643 psi in accordance with ASTM C307.~~
    c. ~~Flexural Strength: 4,300 psi in accordance with ASTM C580.~~
    d. ~~Abrasion Resistance: 0.0 gr in accordance with ASTM D1044.~~
    e. ~~Surface Hardness: 8.5.5 Shore "D" in accordance with ASTM D2240.~~
    a. **Percentage of Active Resin**
        1) **Primer/Sealer: 100.**
        2) **Polymer Concrete: 100.**
        3) **Self-Leveling Topping: 100.**
        4) **Topcoat: 100.**
    b. **Percentage of Solids**
        1) **Primer/Sealer: 100.**
        2) **Polymer Concrete: N/A.**
        3) **Self-Leveling Topping: 100.**
        4) **Topcoat: 100.**
    c. **Water Absorption, Weight Percent: In accordance with ASTM D570.**
        1) **Primer/Sealer: Less than 0.6.**
        2) **Polymer Concrete: 0.2.**
        3) **Self-Leveling Topping: 0.4.**
        4) **Topcoat: 0.4.**
    d. **Tensile Strength, PSI: In accordance with ASTM D638.**
        1) **Primer/Sealer: 3,550.**
        2) **Polymer Concrete: 1,200.**
        3) **Self-Leveling Topping: 1,050.**
        4) **Topcoat: 3,555.**
    e. **Compressive Strength, PSI: In accordance with ASTM C109.**
        1) **Primer/Sealer: N/A.**
        2) **Polymer Concrete: 9,200.**
        3) **Self-Leveling Topping: 6,000-8,000.**
        4) **Topcoat: N/A.**

      f.   Chemical Resistance: In accordance with ASTM D543.
          1)   Effect of Weak Acids: None.
          2)   Effect of Strong Acids: Slight.
          3)   Effect of Alkalis: None.
          4)   Effect of Salt Solutions: None.
          5)   Effect of Oil, Grease: None.
          6)   Effect of Sunlight (UV Radiation): None.

B.   ~~Primer: As recommended by flooring manufacturer.~~

C.   ~~Sealer: Provide with pigmented top coat sealer with slip retardant profile.~~

D.   ~~Color: As selected by the Architect.~~

PART 3 - EXECUTION

3.1   EXAMINATION

A.   Provide for infill slab cure, minimum 28 days or per manufacturer's requirements, whichever is longer

B.   Verify that concrete is free of surface contaminants and concrete laitance, oils, film forming curing or waxy curing compounds, dirt, grease, chemical contaminants, and unbonded coatings.

C.   Verify that substrate concrete moisture is within range acceptable to flooring manufacturer, using a calcium chloride test in accordance with ASTM F1869. Emission rate shall not exceed 3.5 lb/24 hr/1000 sq. ft. Treat with vapor emission treatment systems specified in Section 09 97 25, as required.

D.   Contractor shall report, in writing, surfaces left in improper condition by other trades. Do not proceed until unsatisfactory conditions have been corrected. Application will constitute acceptance of surfaces by the applicator.

3.2   PREPARATION

A.   Preparation of Substrate
    1.   Micro-abrasion method shall be used to remove contaminants, heavy laitance, sharp edges, or protrusions which will interfere with proper bonding of the coating.
    2.   Acid etching should be used only when film forming curing compounds and oils are not present.
        a.   If film forming curing compounds and oils are present, use combination of detergent scrubbing, abrasive blasting, alone or in combination with acid etching.
        b.   Contact manufacturer for recommendations.

B.   Thoroughly mix components in accordance with manufacturer's instructions.

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3.3 APPLICATION

A. Apply components of ~~epoxy~~ **reactive** resin flooring and cove base in accordance with manufacturer's instructions. **Provide appropriate/adequate ventilation during application and curing process per manufacuter's recommendations. Coordinate installation date/time with District's Representative to avoid work during school in-session hours.**

B. Protect adjacent surfaces and related adjacent work from damage.

C. Do not apply coating over standing water or let primer set before applying base coat.

~~D. Trowel topping maintaining 1/4-inch thickness including cove base.~~

~~E~~D. Broadcast anti-skid finish in accordance with manufacturer's instructions.

3.4 PROTECTION

A. Protect the completed work from water, airborne particles, or other surface contaminants until cured and tack free, approximately 18-24 hours after application.

B. Protect completed system from traffic and physical abuse per manufacturer's requirements, approximately ~~72~~ **1-4** hours. Protect completed system from immersion and chemical exposure until thoroughly cured, approximately ~~7 days~~ **1-4 hours** at 70 degrees Fahrenheit.

END OF SECTION

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SECTION 23 09 00

INSTRUMENTATION AND CONTROL PERFORMANCE SPECIFICATIONS

PART 1 - GENERAL

1.1   SUMMARY

A.   Work Included:
1.   Communications
2.   Operator Interface
3.   Controller Software
4.   Web Based Access
5.   BAS Graphics
6.   Building Controllers
7.   Application Specific Controllers
8.   Application Specific Controller - Terminal Unit Controllers
9.   Input/Output Interface
10.   Power Supplies and Line Filtering
11.   Control Panels
12.   Auxiliary Control Devices
13.   Wiring and Raceways
14.   Smoke Detection for Projects with a Building Fire Alarm System

B.   This is a performance specification and Contractor is responsible for design tasks and engineering.

1.2   RELATED SECTIONS

A.   Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3   REFERENCES AND STANDARDS

A.   References and Standards as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B.   In addition, meet the following:
1.   Current edition of ANSI/ASHRAE Standard 135 and addendum, BACnet.
2.   Current edition of UL 916 Underwriters Laboratories Standard for Energy Management Equipment, Canada and the US.
3.   Current edition of FCC Part 15, Subpart J, Class A.
4.   Current edition of BACnet Testing Laboratories (BTL).

1.4   SUBMITTALS

A.   Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B.   In addition, provide:

1. Prepare and submit a detailed schedule of work. Schedule to identify milestones such as equipment submittals, control panel diagrams, color graphic panel displays, Interlock.
2. Wiring diagrams, control program sequence software flow chart diagrams, conduit layout diagrams, device location diagrams, equipment and component deliveries, installation sequencing, controller startup, point to point startup, control programming, sequence testing, commissioning/acceptance testing and training.
3. Submit design drawings, sequences of operation, program listings, software flow charts and details for each typical piece of equipment and system being controlled. No work to be initiated or fabrication of any equipment started prior to the Owner's Representatives return of REVIEWED submittals.
   a. Sequence of Operation: The sequence of operation included in the design documents is intended only to communicate the Engineers' general control intent and is not to be used as a direct reference for programming of the EMS system. Verbatim duplication of the Engineer's Sequence of Operation on the submittals is discouraged and may result in non-approval of the submittal. Sequence of operation on submittals to accurately detail the system's intended programming, and include details of enhancements, adjustments, or deviations from the Engineer's sequence of operation. Submitted sequence of operation to be written with a logical and organized format and flow. Provide detailed, clear and unambiguous sequence of operation language. Point descriptors and point nomenclature referenced in the submitted sequence of operation to match those (to be) actually programmed. As-built submittal Sequence of Operation to include modifications to the programming made as a result of any addendum, bulletins, RFI's, change orders, and commissioning.
4. Format: Make each submittal in one complete and contiguous package. Partial or unmarked submittals will be rejected without review.
5. Submit Manufacturers Data as Follows:
   a. Complete materials list of items proposed to be furnished and installed. A complete Bill of Materials, listing materials, components, devices, wire and equipment are required for this work. The Bill of Materials to be separate for each controller on its own page(s) and to contain the following information for each item listed:
      1) Manufacturer's Name and Model number with furnished options highlighted.
      2) Quantity of each by controller location.
      3) Description of product (generic).
      4) Specified item.
      5) Operating range or span.
      6) Operating point or setpoint.
   b. Manufacturer's specifications and other data required demonstrating compliance with the specified requirements, including but not limited to: Catalog cuts, technical data and descriptive literature on hardware, software, and system components to be furnished.
   c. The data to be clearly marked and noted to identify specific ranges, model numbers, sizes, and other pertinent data. Submit printed manufacturer's technical product data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials and including printed installation instructions and start-up instructions.
   d. Unless specifically called for otherwise, provide bound copies of catalog cuts for standard products, not requiring specifically prepared Shop Drawings, for the following:

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          1)   Wire and Cable, Class II
          2)   Face Plates for Devices
          3)   Disconnect Switches for Power Control

    e.   Where more than one item, size, rating or other variations appear on a catalog cut sheet, clearly identify items to be provided. These items to be properly indexed and referenced to identification numbers, designations and/or details on the Drawings.

6. Shop Drawings: Submit shop drawings for each controlled system, depicting the following information:
    a.   Schematic flow diagram of system showing fans, pumps, coils, dampers, valves and other control/monitoring devices.
    b.   Label each control device with initial setting or adjustable range of control. Label points in schematic diagrams with termination at corresponding controller.
    c.   Electrical Wiring: Clearly differentiate between portions of wiring that are factory installed and portions of be field-installed.
    d.   Details of control panel faces, including controls, instruments, and labeling.
    e.   Interfaces to equipment furnished under other Specification Sections identifying numbers of wires, termination location, voltages and pertinent details. Responsibility for each end of the interfaces to be noted on these drawings whether or not they are a part of this Section.
    f.   System architecture diagram showing the global connectivity of new controllers and any existing systems that will be connected to.

7. Equipment locations, wiring and piping schematics, details, panel configurations, sizes, damper motor mounting details, valve schedules, and a points list keyed to specific hardware submittals. Control wiring depicted as fully annotated ladder diagrams with terminations identified, completely configured as to the exact panel, wiring, relay, switch, and component configuration.

8. Tag Number Lists: Develop instruments tag number system and submit list for approval. Coordinate methods and number block with the Owner Representative.

9. Format the Shop and Field Drawings to Include:
    a.   A Title Sheet containing a drawing list, abbreviations list, symbols list, site and vicinity maps for project location and schedules.
    b.   Floor Plans showing proposed device locations and device nomenclatures.
    c.   A Riser Diagram illustrating conduit relationships between devices shown on the Floor Plans. Show device nomenclatures.
    d.   A Single-Line Diagram for each system showing signal relationships of devices within the system. Show device nomenclatures.
    e.   A Wiring Diagram for each assembly, enclosure or free standing device, showing:
          1)   The Devices Within
          2)   Wiring Connections
          3)   Wire Identification
          4)   Voltage Levels
          5)   Fuse Ratings
    f.   Operations and Maintenance Manuals:
          1)   Following approval of Shop Drawings of control equipment and prior to acceptance of control work, prepare Operating and Maintenance manuals describing operating, servicing, and maintenance requirements of control systems and equipment installed under this Section, in accordance the General and Special Conditions of these Specifications.

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2) Information contained in the manual for the above equipment to include the following:
   a) Manufacturer's catalog cuts and printed descriptive bulletins.
   b) Manufacturer's installation, operating, and maintenance instruction booklets. Complete instructions regarding the operation and maintenance of equipment involved.
   c) Instrument calibration certificates.
   d) Parts list and costs.
   e) Complete nomenclature of replaceable parts, list of recommended spare parts for 12 months operation, their part numbers, current cost and name and address of the nearest vendor of replacement parts.
   f) Name, address and telephone number for closest source of spare parts.
   g) Wiring and schematic diagrams.
   h) Include final record copies of shop drawings.
   i) Copy of guarantees and warranties issued for the various items of equipment, showing dates of expiration.
   j) Reduced plans, diagrams, and control schematics.
   k) Copies of test results.
   l) Control System Operating Manual including: point of summary and point data base; complete printout of program listings; magnetic tape CD or DVD backup of Field Control Cabinet programs; cabinet layout; hard copy of graphic screens; hard copy of specified reports.

g. A final Bill of Quantities including a separate schedule for portable equipment, if delivered as part of this work.

h. Performance, Test and Adjustment Data: Comprehensive documentation of performance verification according to parameters specified in these specifications.

i. Record Drawings: Comply with Division 01, General Requirements and Section 23 00 00, HVAC Basic Requirements. Provide complete as-built submittals including "as-programmed" sequence of operation as well as final occupancy schedules. Controls submittal to be graphics submittal (GUI) clearly showing adjustable set points.

1.5   QUALITY ASSURANCE

A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
   1. Installer Qualifications: Company specializing in performing work of the type specified in this Section with minimum five years' experience in the local area. Installers required to have successfully completed manufacturer's control system factory training.

1.6   WARRANTY

A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

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1.7   SYSTEM DESCRIPTION

A.   Control system referenced throughout specifications and drawings as Building Automation System (BAS), Building Management System (BMS), or Energy Management System (EMS) interchangeably consists of high-speed, peer-to-peer network of DDC controllers, control system server, and operator workstation.

B.   System software based on server/thin-client architecture, designed around open standards of web technology. Control system server accessed using a web browser over control system network, Owner's local area network, and remotely over Internet (through Owner's LAN). Intent of thin-client architecture is to provide operators complete access to control system via web browser. No special software other than web browser required to access graphics, point displays, and trends.

C.   Local Area Network (LAN) either 10 or 100 Mpbs Ethernet network.

D.   System will consist of open architecture that is capable of:
    1.   High speed Ethernet communication using TCP/IP protocol.
    2.   Native BACnet communications according to ANSI / ASHRAE Standard 135, latest edition. Provide necessary BACnet-compliant hardware and software to meet the system's functional specifications. Controller devices must be BTL tested and listed by an official BACnet Testing Laboratory and have the BTL mark issued.

E.   Complete temperature control system to be DDC with electronic sensors and electronic/electric actuation valves and dampers.

F.   Prepare individual hardware layouts, interconnection drawings, building riser/architecture diagram and sequence of control from the project design data. Any architecture diagrams on design drawings have been included as schematics only and are not meant to portray quantity of devices or power/data requirements.

G.   Design, provide, and install equipment cabinets, panels, data communication network infrastructure (including cables, conduits, outlets, connections, etc.) needed, and associated hardware.

H.   Provide complete manufacturer's specifications for items that are supplied. Include vendor name and model number of every item supplied.

I.   Provide a comprehensive operator and technician training program as described in these Specifications.

J.   Provide as-built documentation, operator's terminal software, diagrams, and other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

K.   Provide 120V power, low voltage power, transformers, etc. for control panels, transformer panels, and BAS devices. Install per Division 26, Electrical Specifications. Power for devices within this Specification Section is solely the responsibility of the BAS Contractor.

L.   Conduit and raceway systems. Provide per Division 26, Electrical Specifications.

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M.   Devices, components, controllers, and software to be manufacturer's most current version at the time of installation.

1.8   SYSTEM PERFORMANCE

A.   Performance Standards - System conforms to following minimum standards over network connections:
1.   Graphic Display: Graphic with 20 dynamic points display with current data within 10 seconds.
2.   Graphic Refresh: Graphic with 20 dynamic points update with current data within 8 seconds.
3.   Object Command: Devices react to command of binary object within 2 seconds. Devices begin reacting to command of analog object within 2 seconds.
4.   Object Scan: Data used or displayed at controller or workstation have been current within previous 6 seconds.
5.   Alarm Response Time: Object that goes into alarm is annunciated at workstation within 45 seconds.
6.   Program Execution Frequency: Custom and standard applications are capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
7.   Performance: Programmable controllers are able to completely execute DDC PID control loops at frequency adjustable down to once per second. Select execution times consistent with mechanical process under control.
8.   Multiple Alarm Annunciation: Each workstation on network receive alarms within 5 seconds of other workstations.

B.   Reporting Accuracy: System reports values with minimum end-to-end accuracy listed in Reporting Accuracy Table below.
1.   Reporting Accuracy Table:

Measure Variable	Reported Accuracy
Space Temperature	Plus or Minus 1 degree F
Ducted Air	Plus or Minus 1 degrees F
Outside Air	Plus or Minus 2 degrees F
Dew Point	Plus or Minus 3 degrees F
Water Temperature	Plus or Minus 1 degree F
Delta-T	Plus or Minus 0.25 degree F
Water Flow	Plus or Minus 2 percent of full scale

2.   Note 1: Accuracy applies to 10 percent-100 percent of scale
3.   Note 2: For both absolute and differential pressure
4.   Note 3: Not including utility-supplied meters

C.   Control Stability and Accuracy. Control loops maintain measured variable at setpoint within tolerances listed in Control Stability and Accuracy Table below.
1.   Control Stability and Accuracy Table:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	Plus or minus 0.2 inch wg	0-6 inch wg

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	Plus or minus 0.01 inch wg	-0.1 to 0.1 inch wg
Airflow	Plus or minus 10 percent of full scale	
Space Temperature	Plus or minus 2.00 degrees F	
Duct Temperature	Plus or minus 3.0 degrees F	
Fluid Pressure	Plus or minus 1.5 PSI	1-150 PSI
	Plus or minus 1.0 inch wg	0-50 inch wg differential

PART 2 - PRODUCTS

2.1 NORTHERN CALIFORNIA MANUFACTURERS/INSTALLERS

A. Andover (Schneider Electric)/Steven Engineering, EMCOR Mesa Energy, Alameda Electrical Distributors Inc, Graybar Electric Company Inc, Powermatic Associates

B. Duct/Spot-Type Smoke Detectors (Project with Fire Alarm System):
   1. See Division 28 for Products.

2.2 COMMUNICATIONS

A. Each controller to have communication port for connection to operator interface.
   1. Internetwork operator interface and value passing to be transparent to internetwork architecture.
   2. Operator interface connected to controller to allow operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs to be viewable and editable from each internetwork controller.

B. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers to be readable by each controller on internetwork.

2.3 CONTROLLER SOFTWARE

A. Furnish following applications software for building and energy management. Software applications reside and operate in system controllers. Software to be manufacturer's most current version at the time of installation. Software and associated functions (scheduling, optimum start/stop, etc.) noted in this specification are to be configured and enabled for this project. Incorporate into sequence of operation submittals for review prior to installation.

B. System Security:
   1. User access secured using individual security passwords and user names.
   2. Restrict user passwords to objects, applications, and system functions as assigned by system manager. Provide monitoring only access to Engineer of Record and Commissioning Authority for period of one year for trouble shooting purposes.
   3. Record user Log On/Log Off attempts.
   4. Provide passwords, user names, and access assignments adjustable at the operator's terminal. Each user to have a set security level, which defines access to displays and individual objects the user may control. System to include 10 separate and distinct security levels for assignment to users.

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5. System to include an Auto Logout Feature that will automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period to be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal to display message on screen that user is logged out after Auto Logout occurs.

C. Scheduling: Provide capability to schedule each object or group of objects in system. Coordinate schedule with Owner and program accordingly. Each schedule consists of:
1. Operator's workstation to show information in easy-to-read daily format. Priority for scheduling: Events, holidays and daily with events being the highest.
2. Holiday and special event schedules to display data in calendar format. Operator able to schedule holidays and special events directly from these calendars.
3. Operator able to change information for a given weekly or exception schedule if logged on with the appropriate security access.

D. Optimum Start/Stop: Provide software and program system to start equipment on sliding schedule based upon indoor and outdoor conditions. Determine minimum time of HVAC system operation needed to satisfy space environmental requirements and also determine earliest possible time to stop mechanical systems (i.e. shut down cooling/heating and only provide ventilation one hour prior to scheduled unoccupied period.) Optimum start/stop program operates in conjunction with scheduled start/stop and night setback programs.

E. Alarms:
1. Operator's workstation to provide visual means of alarm indication. The alarm dialog box to always become the top dialog box regardless of the application(s), currently running.
2. System to provide log of alarm messages. Alarm log to be archived to the hard disk of the system operator's terminal. Each entry to include a description of the event-initiating object generating the alarm. Entry to include time and date of alarm occurrence.
3. Alarm messages in user-definable text and entered either at the operator's terminal or via remote communication.
4. Each binary object set to alarm based on operator-specified state.
5. Each analog object have both high and low alarm limits.
6. Alarms must be able to be automatically and manually disabled.
7. Alarms are routed to appropriate workstations based on time and other conditions. An alarm is able to start programs, print, be logged in event log, generate custom messages, and display graphics.
8. System have ability to dial out in event of alarm.
9. Alarm Levels:
    a. Provide 5 levels of alarm as follows, and program alarm levels for every required and specified alarm:
        1) Level 1: Critical/life safety.
        2) Level 2: Significant equipment failure.
        3) Level 3: Non-critical equipment failure/operation.
        4) Level 4: Energy conservation monitor.
        5) Level 5: Maintenance indication, notification.
    b. Prior to training of Owner's representative, submit the complete Points List and suggested Alarm Levels to the Owner.
    c. During training of Owner's representative(s):
        1) Discuss Alarm Levels and the alarms currently included in the BAS.

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      2)   Provide additional alarms without addition of new hardware points, as required by Owner's Representative.

      3)   Agree with the Owner's Representative on action(s) to be taken for each alarm level and implement same for each alarm. Said action to include visual and/or audible alarm(s) at the Operator workstation including whether Operator acknowledgement is required or not, email messages, and text messages.

F.   Demand Limiting:

    1.   System to include demand limiting program that includes two types of load shedding. One type of load shedding to shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding to adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.

    2.   Status of each and every load shed program capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program displayed along with the description of each load.

    3.   Demand-limiting program monitor building power consumption from signals generated by pulse generator (provided by BAS contractor) mounted at building power meter or from watt transducer or current transformer attached to building feeder lines.

    4.   Demand-limiting program predicts probable power demand so that when demand exceeds demand limit, action will be taken to reduce loads in predetermined manner. When demand limit will not be exceeded, action will be taken to restore loads in predetermined manner.

G.   Maintenance Management: System monitors equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits. Coordinate settings with Owner.

H.   Sequencing: Provide application software based upon sequences of operation specified to properly sequence designated systems. Provide points to achieve specified sequences.

I.   Staggered Start: This application prevents controlled equipment from simultaneously restarting after a power outage. Order in which equipment (or groups of equipment) is started, along with time delay between starts to be user-selectable.

J.   Energy Calculations: Provide software to allow instantaneous power (e.g. kW) or flow rates (e.g. L/s (gpm)) to be accumulated and converted to energy usage data.

K.   Anti-Short Cycling: Binary output objects protected from short cycling by allowing minimum on-time and off-time to be selected.

L.   On/Off Control with Differential: Provide algorithm that allows binary output to be cycled based on controlled variable and setpoint. Algorithm direct-acting or reverse-acting and incorporate adjustable differential.

M.   Run-Time Totalization: Provide software to totalize run-times for binary input objects.

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2.4   WEB BASED ACCESS

A.   General Description: BAS supplier to provide web-based access to the system as part of standard installation. Provide access to user of displays of real-time data that are part of the BAS via a standard Web browser. Web browser to tie into the network via Ethernet network connection. Provide web-page host that resides on the BAS network. Web-page software not to require a per user licensing fee or annual fees. The web-page host must be able to support at least 50 simultaneous users with the ability to expand the system to accommodate an unlimited number of users. Software to be manufacturer's most current version at time of installation.

B.   Browser Technology: Browser to be standard version of Microsoft Internet Explorer (latest edition). No special vendor-supplied software needed on computers running browser. Displays viewable and the Web-page host to directly access real-time data from the BAS network. Data displayed in real time and update automatically without user interaction. User able to change data on displays if logged in with the appropriate user name and password.

C.   Display of Data: Web page graphics shown on browser to be replicas of the BAS displays. User to need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays to include animation just as BAS displays. Fans to turn, pilot lights to blink, and coils to change colors, and so on. Real-time data shown on browser Web pages. This data must be directly gathered via the BACnet network and automatically updated on browser Web page displays without any user action. Data on the browser to automatically refresh as changes are detected without re-drawing the complete display. User to be able to change data from browser Web page to if the user is logged on with the appropriate password. Clicking on a button or typing in a new value to change digital data. Using pull-down menus or typing in a new value to change analog data. Data displays navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

D.   Web Page Generation: Web pages generated automatically from the BAS displays that reside on the BAS server. User to access Web-page host via the network and initiate a web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access via any computer's standard browser. Any system that requires use of an HTML editor for generation of Web pages will not be considered.

E.   Password Security and Activity Log: Access via Web browser to utilize the same hierarchical security scheme as BAS system. User asked to log in once the browser makes connection to Web-page host. Once the user logs in, any changes that are made to be tracked by the BAS system. User able to change only those items that the user has authority to change. A user activity report to show any activity of the users that have logged in to the system regardless of whether those changes were made using a browser or via the BAS workstation.

F.   Communication: Web-page host to communicate using the specified protocol standard to devices on the BAS network.

2.5 **BAS GRAPHICS**

A. Develop customized graphics showing the project building(s) and their floor plans, mechanical, and electrical equipment, flow and control diagrams, and other relevant features on Workstation graphic screens. Associated input, output, and virtual objects (e.g., temperature and pressure setpoints) listed in the Sequence of Operation, and shown on the Input/Output Objects List included in the graphic screens and bound to the database. Real-time value of objects updated on the display of each graphic automatically. For projects where existing campus and/or building controls systems exist, replicate graphics used in the existing BAS graphics screens.

B. Graphics to have links to the Print function and to display a Standard Legend in the corner of the graphic. Graphics, except pop-ups, to have the date and time displayed in the upper corner of the graphic. Each graphic titled.

C. Weather: Graphics, except pop-ups, to have the outdoor temperature and humidity in the upper corner of the graphic.

D. Alarms: System and component summary alarms located near the top of each relevant graphic screen. Provide links to the associated system/component as part of these tags to assist trouble shooting. Other alarms placed near the associated system/device as depicted in the graphic. Provide text and color of information tags that describe each object and alarm value consistent with a graphics color legend.

E. The Following Graphics Provided as a Minimum:
   1. A building graphic, typically a photograph of the building, with links to each floor plan and other links as defined below.
   2. A central plant graphic with equipment (chillers, boilers, pumps, heat exchangers, storage tanks, etc.), temperature sensors, pressure sensors, flow sensors and refrigeration leak detectors. The central plant graphic to have links to each building on the campus.
   3. Central equipment such as air handler, package rooftop equipment, supply fans, exhaust fans, and smoke control systems.
   4. Floor plans of each floor, with temperature sensors, pressure sensors, temperature control zones, heating/cooling zones, ventilation zones, and supply air zones identified. Rooms grouped on a graphic only to the extent that detailed and complete sensing information can be comfortably viewed by an operator and the bound points updated in less than 10 seconds. Each zone to have a temperature symbol that changes color over the range from low (blue) through normal (green) to high (red) and indicate an alarm (flashing red). The zone temperature and or pressure symbol(s) to be a link to a zone control pop-up graphic. Individual floor plan graphics to provide links to related mechanical systems. The mechanical room plan graphics to show the relative location of, and provide links to, either the equipment pop-up or flow and control graphic for mechanical equipment monitored or controlled by the BAS.
   5. Pop-up graphics provided for each zone control system showing a flow diagram and related monitoring and control points and system parameters. Pop-up graphics provided for each piece of equipment that is not shown on a flow and control graphic.
   6. Flow and control diagrams for each system including but not limited to fan coils, chilled water systems, heating hot water systems, zone terminal units, combination fire and smoke damper status, and ventilation systems. The flow and control graphics to have parameters grouped in the lower portion of the graphics. Standard equipment graphics

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used. Pumps, fans, dampers and other elements to dynamically indicate their state (i.e. pumps and fans to rotate when on and damper positions to dynamically adjust and be shown in their current position, etc.). System flow and control graphics displayed in a general left to right flow or loop arrangement. Return and exhaust air flow shown on top and return water shown on the bottom of the graphic.

7. Individual equipment/component screens showing sensing and control information available for each device provided.

F. Penetration: The graphic interface to consistently apply a convention whereby a left-click to always penetrate to more detailed information. The text windows to represent the deepest level of penetration. A right-click to always produce a menu of options that are specific to the item selected.

G. Navigation: Graphics organized to provide a "branching structure" that allows an operator to move from a "macro view" to a "micro view" and return. These links to other associated graphics, or allow a return to a previous macro view, provided and arranged horizontally along the bottom of each graphic screen. From left to right, the graphic links as follows: site/building map, building/trailer floor plans, and major mechanical systems at each building. Pop-up right click menus provided as needed on the lower button bar to allow for uncluttered navigation.

H. Clutter Minimization: Each graphic to have separate check boxes in the lower right corner that show/hide setpoints, alarms/safeties, and devices/equipment.

I. Templates: To the maximum extent possible, use standard graphics as templates to provide a consistent look throughout the interface.

J. Color Scheme: The graphics to use dynamic color changes to communicate equipment type, or object status consistent with the graphics color legend.

K. Symbols and Animations: Fans, pumps, dampers, coils, and generation equipment to be dynamic symbols indicating rotation, state, or position, movement, flow, etc.

L. Macros: When macros are used to add functionality to the graphics, detailed documentation provided.

M. Configure Mode: Access to "Configure Mode" for editing of the graphics password protected to prevent unauthorized changes to the graphics. This password supplied to the appropriate personnel.

N. Graphics Version: Graphics provided in the most current format available at time of control system programming.

O. Points and graphics checked for the proper binding and graphic programming, settings to ensure that the correct system, location, point values and dynamics are shown in the proper location and rotate in the proper directions.

P. After graphics have been accepted, provide, on a CD ROM in an agreed upon file structure. If the graphics have active-x controls or other files that must be placed outside the graphics folder structure a set-up program provided on the disk to place the files in the correct locations.

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2.6   BUILDING CONTROLLERS

A.   General: Provide adequate number of building controllers to achieve performance specified. Panels to meet the following requirements.
1.   Building Automation System (BAS) to be composed of one or more independent, stand-alone, microprocessor-based building controllers to manage global strategies described in Controller Software article.
2.   Provide sufficient memory to support operating system, database, and programming requirements.
3.   Share data between networked building controllers.
4.   Distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5.   Controllers that perform scheduling have real-time clock.
6.   Continually check status of its processor and memory circuits and if abnormal operation is detected, controller:
a.   Assume predetermined failure mode.
b.   Generate alarm notification.
7.   Building Controller communicates with other devices on internetwork including BACnet communications according to specified protocol.

B.   Communication:
1.   Each building controller resides on network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and performs routing to network of custom application and application specific controllers.
2.   Controller provides a service communication port for connection to a portable operator's terminal.

C.   Environment:
1.   Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
2.   Controllers used in conditioned space are mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D.   Keypad: Local keypad and display to be provided for each controller. Security password to be available to prevent unauthorized use of keypad and display.

E.   Serviceability: Provide diagnostic LEDs for power, communication, and processor. Wiring connections are made to modular terminal strips or to termination card connected by ribbon cable.

F.   Memory: Building controller maintains BIOS and programming information in event of power loss for at least 72 hours.

G.   Immunity to power and noise. Controller able to operate at 90 percent to 110 percent of nominal voltage rating and performs an orderly shutdown below 80 percent nominal voltage. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3-feet.

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H.   Controller to have a battery to provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup to maintain real-time clock functions for a minimum of 10 days.

2.7   APPLICATION SPECIFIC CONTROLLERS

A.   Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers to be fully programmable using graphical programming blocks.
1.   ASC controllers communicate with other devices on internetwork.
2.   Each ASC capable of stand-alone operation without being connected to network.
3.   Each ASC will contain sufficient I/O capacity to control target system.
4.   Application controllers to include universal inputs with minimum 10-bit resolution that accept thermistors, 0-10VDC, 0-5 VDC, 4-20 mA and dry contact signals. Any input on a controller may be either analog or digital with at least 1 input that accepts pulses. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller to include binary and analog outputs on board. Provide analog outputs switch selectable as either 0-10VDC or 0-20mA. Software to include scaling features for analog outputs. Application controller to include 24VDC voltage supply for use as power supply to external sensors.
5.   Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI and PID loops for control of multiple devices. Calculations completed using floating-point math and system to support display of information in floating-point nomenclature at operator's terminal. Programming of application controller completely modifiable in the field over installed BAS LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen.
6.   Application controller to include support for room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Provide button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

B.   Communication:
1.   Controller resides on network using MS/TP Data Link/Physical layer protocol.
2.   Each controller connected to building controller.
3.   Each controller capable of connection to laptop computer or portable operator's tool.

C.   Environment:
1.   Controllers used outdoors and/or in wet ambient conditions mounted within NEMA waterproof enclosures and rated for operation at 0 degrees F to 150 degrees F.
2.   Controllers used in conditioned space mounted in NEMA dust-proof enclosures and rated for operation at 32 degrees F to 120 degrees F.

D.   Serviceability: Provide diagnostic LEDs for power, communication, and processor.

E.   Memory: ASC use nonvolatile memory and maintains BIOS and programming information in event of power loss.

2.8   APPLICATION SPECIFIC CONTROLLER - TERMINAL UNIT CONTROLLERS

A.   Provide one application controller for each terminal unit that adequately covers objects listed in object list for unit. Controllers to interface to building controller via LAN using specified protocol. Controllers to include on board flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B.   Application controllers to include universal inputs with 10-bit resolution that can accept thermistors, 0-5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller to also include support and modifiable programming for interface to intelligent room sensor with digital display (digital display to indicate setpoint only). Controller to also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0-10 V or 0-20 mA control signals. Application controller to include microprocessor driven flow sensor for use in pressure independent control logic. Terminal units controlled using pressure independent control algorithms and flow readings to be in CFM.

C.   Program sequences stored on board application controller in EEPROM. No batteries needed to retain logic program. Program sequences executed by controller 10 times per second and capable of multiple PI loops for control of multiple devices. Provide programming of application controller completely modifiable in the field over installed specified protocol LANs or remotely via modem interface. Operator to program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller programmed using the same programming tool as Building Controller and as described in Operator Workstation article.

D.   Application controller to include support for intelligent room sensor. Display on room sensor programmable at application controller and include an operating mode and a field service mode. Button functions and display data programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence for specific display requirements for intelligent room sensor.

E.   Provide duct temperature sensor at discharge of each terminal unit that is connected to controller for reporting back to operator workstation. Provide analog inputs for the duct temperatures.

2.9   INPUT/OUTPUT INTERFACE

A.   Input/output points protected such that shorting of point to itself, to another point, or to ground will cause no damage to controller. Input and output points protected from voltage up to 24 V.

B.   Binary inputs (BI or DI) allow monitoring of On/Off signals from remote devices. Binary inputs sense "dry contact" closure without external power (other than that provided by controller) being applied.

C.   Pulse accumulation input objects accept up to 10 pulses per second for pulse accumulation.

D.   Analog inputs (AI) allow monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD).

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E.   Binary outputs (BO or DO) provide for On/Off operation or pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers have three-position (On/Off/Auto) override switches and status lights. Outputs selectable for either normally open or normally closed operation.

F.   Analog outputs (AO)provide a modulating signal for control of end devices. Outputs provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building controllers have status lights and two-position (AUTO/MANUAL) switch and adjustable potentiometer for manual override. Analog outputs not exhibit drift of greater than 0.4 percent of range per year.

G.   Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms run zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.10   POWER SUPPLIES AND LINE FILTERING

A.   Control transformers UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits. Limit connected loads to 80 percent of rated capacity.

B.   DC power supply output match output current and voltage requirements. Unit operates between 32 degrees F and 120 degrees F.

C.   Line voltage units UL listed and CSA approved.

D.   Power line filtering. Provide transient voltage and surge suppression for workstations and controllers.

2.11   CONTROL PANELS

A.   Control Panels:
1.   Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures to be NEMA 12 when installed in other than a clean environment. Outdoor enclosures must be NEMA 3R. Provide (hinged door) key-lock latch and removable subpanels. Single key common to field panels and subpanels. In existing campus or building settings, key lock to match existing keys.
2.   Interconnections between internal and face-mounted devices prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection individually identified per control drawings.
3.   Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.
4.   Provide laminated plastic nameplates for enclosures in any mechanical room or electrical room labeled with TCP number. Laminated plastic to be 1/8-inch thick sized appropriately to make label easy to read.

2.12   AUXILIARY CONTROL DEVICES

A.   Temperature Instruments:
1.   Room Temperature Sensor: Thermistor or platinum RTD type with accuracy of plus or minus 0.5 degrees F at 70 degrees F; operating range 30-120 degrees F; linear signal; single point sensing element in wall-mounted ventilated enclosure with insulating back plate if mounted on exterior wall; push button for occupancy override; digital setpoint adjustment plus or minus 2 degrees F in both directions; LCD temperature display indicating setpoint only. Setpoint adjustment to revert to building programmed standard temperature upon next building occupancy schedule change (user adjustable). Room temperature sensor may have integral space carbon dioxide sensor with minimum performance characteristics identified within this specification. Include integral occupancy sensor for public rooms but not in offices.
2.   Averaging Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of array of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 1-foot element per 2 SF of duct cross-sectional area. Use when duct is 9 SF or larger or where air is subject to temperature stratification.
3.   Probe Duct Temperature Sensors: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F, consisting of single point sensing elements, securely mounted in duct or plenum; operating range 20-120 degrees F; linear signal; 24-inch rigid probe. Use where duct is less than 9 SF cross-sectional area.
4.   Outside Air Temperature Sensor: Thermistor or platinum RTD element with accuracy of plus or minus 0.5 degrees F at 32 degrees F; Range -58 to 120 degrees F, single element, linear, with weather and sun shield for exterior mounting.
5.   Low Temperature Limit Thermostat: Minimum 20 foot capillary sensing element, triggering on low temperature as sensed by any 12-inch segment; snap acting, normally open contacts, manual reset, line voltage.
6.   Liquid Immersion Temperature Sensor: Thermistor or platinum RTD element, with accuracy of plus or minus 0.5 degrees F at 32 degrees F, stainless steel well and assembly, range 30 to 250 degrees F.

B.   Pressure Transmitters and Transducers:
1.   Transducer have linear output signal; field adjustable zero and span. Sensing elements withstand continuous operating conditions of positive or negative pressure 50 percent greater than calibrated span without damage.
2.   Differential Pressure Switch: Setpoint adjustable with operating range of 0.5 to 12-inch WG for fans, and 5 to 30-feet WC for pumps. Switches UL listed; SPDT snap-acting; pilot duty rated (125 VA minimum); NEMA 1 enclosure; scale range and differential suitable for intended application.
3.   Filter Differential Pressure Switch: Setpoint adjustable with operating range of 0.1 to 5-inch WG; auto reset. Contactor to close when pressure differential setting is met or exceeded. Provide mounting bracket, metallic tubing and appropriate fittings for connection to duct or air-handling unit.
4.   Duct Static Differential Pressure Transducer: Operating range 0 to 5-inch WC for duct mounted transmitter; ceramic capacitive sensing element with probe securely mounted in duct; digital input terminal and push button to zero output. Accuracy plus or minus 1 percent of full scale; maximum response time 2 seconds.

5.   Building Static Pressure Transducer: Operating range of -0.1 to 0.1-inch WC, linear signal. Sensing tubes located inside and outside building use shielding and/or surge tanks to minimize effects of wind. Accuracy plus or minus 1 percent of full scale.

6.   Piping Pressure Transmitter: Operating range 0 to 50 PSIG, linear signal; stainless steel diaphragm; digital input terminal and push button to zero output. Accuracy plus or minus 1 percent of full scale.

C.   Motorized Control Dampers:

1.   Performance: Maximum leakage of 3 CFM/SF at 1-inch WG differential pressure, AMCA Class 1A, maximum pressure rating of 13-inch WG differential pressure, maximum velocity of 6,000 fpm, -72 degrees F to 275 degrees F temperature rating.

2.   Multi-blade type, except where either dimension is less than 10-inch single blade may be used. Maximum blade length to be 48-inch.

3.   Provide parallel blades for modulating mixing service and opposed blades for throttling service.

4.   Blades to be interlocking; minimum 16 gauge galvanized steel; compression type edge seals and side seating stops. In copper, aluminum and stainless steel duct work, damper material matches duct work material.

5.   Damper blades are reinforced, have continuous full length axle shafts, axle to axle linkage, and/or operating "jackshafts" as required to provide coordinated tracking of blades.

6.   Bearings: Self-lubricating stainless steel sleeve or Celcon bearing.

7.   Dampers over 25 SF in area to be in two or more sections, with interconnected blades.

8.   Provide remote damper blade position status with binary input.

9.   Tested in accordance with AMCA Standard No. 500.

D.   Motorized Control Valves:

1.   Body pressure rating and connection type construction conforms to pipe, fitting and valve schedules.

2.   Fluid valve close-off ratings and spring ranges operate at maximum flows and maximum available pump heads scheduled without leakage.

3.   Screwed ends except 2-1/2-inch and larger valves with flanged ends.

4.   Motorized Control Valves (Pressure Independent Control Valves):

a.   Description: Valve consists of pressure compensating cartridge, actuated ball or Y pattern globe valve, and multiple pressure/temperature test ports in a single valve housing.

b.   Construction: Rated for no less than 125 PSI and 250 degrees F. 2-inch and Smaller: brass with threaded connections. 2-1/2-inch and larger: cast iron with flanged connections.

c.   Performance: Flow rate controlled linearly to within 5 percent of target flow rate, for any actuator position (0 to 100 percent), over an operating differential pressure range of 6 to 50 PSI across the valve. Provide valve with integral test ports to verify pressure differential.

d.   Manufacturers: Belimo, Danfoss, Flow Control Industries, Griswold, Tour and Andersson or equal.

5.   Fluid three-way valves globe valves with linear plug with composition disc for tight shutoff.

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6. Pressure drop equal to twice pressure drop through heat exchanger (load), 50 percent of pressure difference between supply and return mains, or 5 PSI, whichever is greater, except two-position valves to be line size.

E. Electric Damper/Valve Actuators:
   1. Provide mechanical or electronic stall protection for each actuator.
   2. Where indicated provide internal mechanical, spring-return mechanism or provide uninterruptible power supply (UPS). Non-spring-return actuators have external manual gear release to position damper/valve when actuator is not powered.
   3. Proportional actuators accepts 0 to 10 VDC or 0 to 20 mA control signal and provide 2 to 10 VDC or 4 to 20 mA operating range.
   4. Actuator sized for torque required plus 25 percent; UL or CSA listed; electronic current overload protection.
   5. VAV Actuators: Actuators proportional 24 VAC actuators using a 4 to 20 mA range of control signals; stops automatically at end of travel; include permanently lubricated gear train.

F. Air Flow Meters:
   1. Fan Inlet Type: Self-supporting aluminum traverse probes housing thermal dispersion sensors. Probe spacing and sensor quantity as recommended by manufacturer. Provide factory calibrated electronic flow transmitter with CFM readout display and capability of providing 4 to 20 milliamp output for interface with direct digital controls. Ebtron GTx116-PC.
   2. Duct Mounted Air Flow Station: Self-supporting aluminum alloy tube with stainless steel mounting brackets. Probe and sensor density quantity as recommended by manufacturer. Sensor use thermal dispersion technology with two "bead in glass," hermetically sealed thermistor probes at each measuring point. Provide electronic flow transmitter with CFM readout display and capable of 4-20 mA output signal. Ebtron GTA116-PC.

G. Room Pressure Monitor: Active room pressure monitor and alarm which provides local audio alarm and analog and alarm signals to DDC system. Wall mounted panel with LED differential pressure readout; audible and visual alarm; mute button; range of -0.05 to +0.05-inch WC; accurate to 1 percent of full scale; repeatability plus or minus 1.0 percent of full scale per year, alarm delay ability between 0-30 seconds. Provide door switch to deactivate alarm when space door(s) are open. Input status from BAS to deactivate alarm in unoccupied or shutdown modes. Phoenix Controls APM100.

H. Wall Mounted Space Carbon Dioxide Sensor:
   1. Sensor to employ non-dispersive infrared technology. (N.D.I.R.)
   2. Sensor Repeatability: Plus or minus 20 ppm. 0-2000.
   3. Sensor Accuracy: Less than or equal to 75 ppm over 0-1500 ppm range.
   4. Sensor Response Time: Less than 1 minute.
   5. Sensor to employ reference channel design for long-term stability.
   6. Sensor to have field selectable 0-10VDC, or 4-20mA outputs.
   7. Sensor power requirement less than 3W.
   8. Sensor Input Voltage: 20 to 30VAC/DC.
   9. Sensor Operating Temperature Range: 0 degrees C to 50 degrees C.
   10. Sensor to have models for wall mounting or duct mounting.
   11. Sensor to provide at least a 1-year factory warranty from date of purchase.
   12. Sensor to match cover in color and look to temperature sensor.

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13. Sensor to have display.
14. Manufacturers:
    a. Telaire
    b. Vaisala
    c. Veris

I. Occupancy Sensor: Dual technology infrared and ultrasonic sensing device, ceiling or wall mounted, built-in self-adjusting settings, timer settings of 30 seconds to 30 minutes, with manual and automatic modes. Provide multiple devices in parallel when area served is greater than a single device sensing capability. Provide integral power pack, 120 VAC input, 24 VDC output, with manual override switch. Leviton OSC-MOW series.

J. Relays:
1. Control relays UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage to be suitable for application.
2. Time delay relays UL listed solid-state plug-in type with adjustable time delay. Delay adjustable plus or minus 200 percent (minimum) from setpoint or as indicated. Contact rating, configuration, and coil voltage to be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

K. Override Timers: Override timers spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer suitable for flush mounting on control panel face and located on local control panels or where shown.

L. Current Transmitters:
1. AC current transmitters are self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit range compatible with actual applied span of current value, with internal zero and span adjustment and plus or minus 1 percent full-scale accuracy at 500 ohm maximum burden.
2. Transmitter meets or exceeds ANSI/ISA S50.1 requirements and UL/CSA recognized.
3. Unit split-core type for clamp-on installation on existing wiring.

M. Current Transformers: AC current transformers UL/CSA recognized and completely encased (except for terminals) in approved plastic material; plus or minus 1 percent accuracy at 5 A full-scale.

N. Voltage Transmitters: AC voltage; self-powered single-loop (two-wire) type; 4 to 20 mA output with zero and span adjustment; UL/CSA recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1. Ranges include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with plus or minus 1 percent full-scale accuracy with 500 ohm maximum burden.

O. Voltage Transformers: AC voltage transformers UL/CSA recognized, 600 VAC rated; built-in fuse protection; suitable for ambient temperatures of 40 degrees F to 130 degrees F; plus or minus 0.5 percent accuracy at 24 VAC and a 5 VA load.

P. Power Monitors: Selectable rate pulse output for kWh reading; 4-20 mA output for kW reading; N.O. alarm contact; ability to operate with 5.0 amp current inputs or 0-0.33 volt inputs;

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plus 1.0 percent full-scale true RMS power accuracy; plus 0.5 Hz, voltage input range 120-600 V, and auto range select; NEMA 1 enclosure. Current transformers having a 0.5 percent FS accuracy, 600 VAC isolation voltage with 0-0.33 V output. If 0-5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

Q.   Emergency Stop Switch: Red, mushroom type, pull out to operate.

R.   End Switches: Turret head Type SPDT. Schneider Electric/Square D Class 9007, Type C54B2, or equal.

2.13   WIRING AND RACEWAYS

A.   General: Provide copper wiring, plenum cable, and raceways as specified in applicable Sections of Division 26, Electrical.

B.   Insulated wire to be copper conductors, UL labeled for 90 degrees C minimum service.

C.   Field panels and controllers to be supplied by building emergency power system where systems being monitored or controlled are on emergency power.

D.   Run control wiring as follows:
1.   Mechanical Rooms: In conduit.
2.   Exposed in Building Spaces: In conduit.
3.   Concealed in Building Walls and Ceilings: Plenum rated cable.
4.   Concealed in Building Ceilings: Plenum rated cable in cable tray.

E.   Field and Subfield Panels: Voltage in panels not-to-exceed 120 volts.

F.   Motor Control Centers: Responsibility for correct voltage of holding coils and starter wiring in pre-wired motor control centers interfacing with automatic controls is included hereunder.

G.   Wiring for BAS systems communications buses two conductor minimum 18 gauge foil-shielded, stranded twisted pair cable rated at 300 VDC or more than 80 degrees C.

2.14   SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

A.   See Division 28 for Products.

PART 3 - EXECUTION

3.1   DEMOLITION

A.   Terminal Devices: Remove terminal sensors, actuators and controls as indicated on drawings and as required to accommodate scope of mechanical work shown on drawings and described in specifications. Remove pneumatic piping and cap with hardware as appropriate. Remove wiring and conduit associated with devices. Do not leave any unused abandoned piping or wiring in space.

B.   Graphics and Programming: Remove symbols from control system graphics associated with deleted terminal elements. Modify programming code to delete alarms, control loops, etc., associated with deleted terminal devices.

3.2 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owners' representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until unsatisfactory conditions are resolved.

3.3 CONTROL SYSTEM CHECKOUT AND TESTING

A. Testing completed before Owner's representative is notified of system demonstration.

B. Calibrate and prepare for service of instruments, controls, and accessory equipment furnished under this specification.

C. Verify that control wiring is properly connected and free of shorts and ground faults.

D. Enable control systems and verify calibration and operation of input and output devices.

E. Verify that system operation adheres to sequences of operation.

F. Commissioning and Verification: In addition to commissioning requirements specified elsewhere, provide the following commissioning on the HVAC instrumentation and controls system:
1. Control systems completely commissioned to ensure aspects of the system are operating as intended and at optimum tuning.
2. Wiring connections verified and traced from field device to panel to ensure proper connections.
3. Measured values verified by a hand held calibrated device to validate that value indicated by the control system is in fact the actual measured value.
4. Loops properly tuned to obtain the desired control value. Each loop to be "upset" and put back in control to demonstrate its ability to stabilize quickly.
5. Provide a final point-by-point report submitted that indicates the date of each verification, the results, and initialed on each page by the person performing the reading.

3.4 ACCEPTANCE TESTING AND TRAINING

A. Site Testing:
1. Contractor provides personnel, equipment, instrumentation, and supplies necessary to perform testing. Owner or Owner's representative will witness and sign off on acceptance testing.
2. Contractor demonstrates compliance of completed control system with Contract Documents. Using approved test plan, physical and functional requirements of project demonstrated.

B. Training:
1. General: Contractor conducts training courses for up to three other designated personnel in operation and maintenance of system. Training manuals provided for each trainee, with two additional copies provided for archival at project site. Manuals include detailed

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description of subject matter for each lesson. Copies of audiovisuals delivered to Owner. Training day is defined as 8 hours of classroom instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during normal first shift in effect at training facility. Notification of any planned training given to Owner's representative at least 15 days prior to training.

2. Operator's Training I: First course taught at supplier's facility for period of one training day. Upon completion, each student should be able to perform elementary operations with guidance and describe general hardware architecture and functionality of system.

3. Operator's Training II: Second course taught at project site for a period of one training day after completion of contractor's field testing. Course includes instruction on specific hardware configuration of installed system and specific instructions for operating installed system. Upon completion, each student should be able to start system, operate the system, recover system after failure, and describe specific hardware architecture and operation of system.

4. Operator's Training III: Third course taught at project site for period of one training day no later than six months after completion of the acceptance test. Course will be structured to address specific topics that students need to discuss and to answer questions concerning operation of system. Upon completion, students should be fully proficient in system operation and have no unanswered questions regarding operation of installed system.

3.5   WIRING

A.   Provide electrical wiring required to control systems specified in this Section. Control and interlock wiring complies with national, state and local electrical codes and Division 26, Electrical of this specification.

B.   Power wiring required for building control panel(s) to be dedicated circuit(s).

C.   Verify location of operator work station with Owner prior to installation.

D.   NEC Class 1 (line voltage) wiring UL Listed in approved raceway according to NEC and Division 26, Electrical requirements.

E.   Low-voltage wiring meets NEC Class 2 requirements. (Low-voltage power circuits subfused when required to meet Class 2 current limit.)

F.   Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for intended application.

G.   Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for purpose of interfacing (e.g., relays and transformers).

H.   Where Class 2 wiring is run exposed, wiring run parallel along surface or perpendicular to it and tied at 10 foot intervals.

I.   Where plenum cables are used without raceway, support from structural members. Do not support cables with ductwork, electrical raceways, piping, or ceiling suspension systems.

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J. Make wire-to-device connections at terminal block or terminal strip. Make wire-to-wire connections at terminal block.

K. Maximum allowable voltage for control wiring 24 V. If only higher voltages are available, provide step-down transformers.

L. Wiring installed as continuous lengths, with no splices permitted between termination points.

M. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at penetrations.

N. Include one pull string in each raceway 1-inch or larger.

O. Control and status relays are to be located in designated enclosures. Enclosures include packaged equipment control panels unless they also contain Class 1 starters.

P. Install raceway to maintain a minimum clearance of 6-inches from high-temperature equipment (e.g., steam pipes or flues).

Q. Secure raceways with raceway clamps fastened to 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.

R. Install insulated bushings on raceway ends and openings to enclosures. Seal top end of vertical raceways.

S. Flexible metal raceways and liquid-tight, flexible metal raceways not-to-exceed 3-feet in length and be supported at each end. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways to be used.

T. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections joined with couplings. Terminations made with fittings at boxes.

U. Input and output terminations to be labeled at the controller to identify if they are AI, DI, AD, DO, and function (i.e. pump start, OM Sensor).

3.6 COMMUNICATION WIRING

A. Follow manufacturer's installation recommendations for communication cabling.

B. Verify integrity of network following cable installation.

C. Communication wiring unspliced length when that length is commercially available; labeled to indicate origination and destination data.

D. Grounding of coaxial cable in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.7 INSTALLATION OF AUXILIARY CONTROL DEVICES

A. General:

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1. Install sensors and thermostats in accordance with manufacturer's recommendations.
2. Room sensors and thermostats installed at 48-inches AFF to midline of sensor on concealed junction boxes properly supported by wall framing at the locations shown on the Drawings.
3. Low-limit sensors used in mixing plenums installed in a serpentine manner horizontally across duct.
4. Pipe-mounted temperature sensors installed in wells with heat-conducting fluid in thermal wells.
5. Install outdoor air temperature sensors on north facing wall or screen, complete with sun shield at designated location.

B. Actuators:
1. General:
    a. Mount and link control damper actuators according to manufacturer's instructions.
    b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
2. Actuator Mounting for Damper and Valve Arrangements to Comply with the Following:
    a. Damper Actuators: Do not install in the air stream.
    b. Use a weather proof enclosure (clear and see through) if actuators are located outside.
    c. Damper or valve actuator ambient temperature not-to-exceed 122 degrees F through any combination of medium temperature or surrounding air. Provide appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation as necessary. Mount per manufacturer's recommendations.
    d. Actuator cords or conduit to incorporate a drip leg if condensation is possible. Do not allow water to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point to be avoided to prevent water from condensing in conduit and running into actuator.
    e. Damper mounting arrangements to comply with the following:
        1) Furnish and install damper channel supports and sheet metal collars.
        2) Jack shafting of damper sections not allowed.
        3) Multi-section dampers arranged so that each damper section operates individually. Provide one electronic actuator direct shaft mounted per section.
    f. Size damper sections based on actuator manufacturers specific recommendations for face velocity, differential pressure and damper type. In general: Damper section not-to-exceed 24 ft-sq. with face velocity 1500 FPM.
    g. Multiple section dampers of two or more arranged to allow actuators to be direct shaft mounted on the outside of the duct.
    h. Multiple section dampers of three or more sections wide arranged with a 3-sided vertical channel (8-inch wide by 6-inch deep) within the duct or fan housing and between adjacent damper sections. Vertical channel anchored at the top and bottom to the fan housing or building structure for support. Connect sides of each damper frame to the channels. Holes in the channel to allow damper drive blade shafts to pass through channel for direct shaft mounting of actuators. Face open side of channel downstream of the airflow, except for exhaust air dampers.
    i. Multiple section dampers to be mounted flush within a wall or housing opening to receive either vertical channel supports as described above or sheet metal standout

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collars. Sheet metal collars (12-inch minimum) to bring each damper section out of the wall to allow direct shaft mounting of the actuator on the side of the collar.

C. Control Valve:
1. Valves installed in accordance with manufacturer's recommendations.
2. Slip-stem control valves installed so that stem position is not more than 60 degrees from vertical up position. Ball type control valves installed with stem in horizontal position.
3. Control valves accessible and serviceable.
4. Install isolation valves so that control valve may be serviced without draining supply/return side piping system. Install unions at connections to screw-type control valves.
5. Valve Sizing for Water Coil:
   a. On/Off Control Valves: Line size.
   b. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than 1/2 the pipe size. BAS contractor to size water coil control valves for the application as follows:
      1) Booster-heat valves sized not-to-exceed 4-9 PSI differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      2) Primary valves sized not-to-exceed 5-15 PSI differential pressure. Size valve for 50 percent valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      3) Butterfly valves sized for modulating service at 60 to 70 degree rotation. Design velocity 12-feet per second or less when used with standard EPDM seats.
   c. Valve Mounting Arrangements to Comply with the Following:
      1) Provide unions on ports of two-way and three-way valves.
      2) Install three-way equal percentage Characterized Control valves in a mixing configuration with the "A" port piped to the coil.
      3) Install 2-1/2-inch and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

D. Control Damper:
1. Dampers installed in accordance with manufacturer's instructions. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
2. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

E. Air Flow Station: Install where indicated in ductwork and/or equipment with manufacturer's recommended straight ductwork upstream and downstream of air flow station or as shown on drawings, whichever is greater. Where equipment manufacturer's standard airflow measuring station cannot read airflows at required design velocities, provide appropriate air flow measuring station to provide accurate reading throughout system design operations range.

3.8 SMOKE DETECTION (FOR PROJECTS WITH A FIRE ALARM SYSTEM)

A. Smoke detector furnished and powered/wired under Division 28, Electronic Safety and Security. Coordinate with fire alarm equipment supplier. Installation of duct smoke detector housing and sampling tube under Division 23, HVAC.

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B.   Install smoke detectors in supply air systems greater than 2000 CFM.

3.9   SEQUENCES OF OPERATION AND POINTS LISTS

A.   Where local energy code dictates certain sequences (such as night setback, night flush, pressure and temperature reset, terminal unit sequences, etc.), the sequences are not necessarily repeated in the documents. It is not the intent of this specification or documentation to reiterate the energy code. Provide energy code mandated sequences and document in sequence of operations submittals at no additional cost to the Owner. Provide required points to achieve the appropriate sequences.

B.   See control diagrams and sequences on drawings in addition to sequences below.

C.   Variable Frequency Drives: For a VFD dependent on an external input for its output setting (e.g., the VFD gets "Frequency" as an input), loss of that external input to result in the VFD holding its last value. If the VFD is running its own PID loop and the external input to the VFD is a setpoint (e.g. duct static pressure setpoint), the VFD to hold the last setpoint. If the VFD loses its process variable (e.g. duct static pressure), the VFD to go to its minimum speed setting.

D.   Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials to be centered on the associated setpoint. Modulating feedback control loops to include the capability of having proportional, integral, and derivative action. Unless the loop is specified "proportional only" or "P+I", Contractor to apply appropriate elements of integral and derivative gain to each control loop to result in stable operation, minimum settling time and maintain the primary variable within the specified maximum allowable variance.

E.   Provide a real time clock and schedule controller with sufficient scheduling capability to schedule required controllers and sequences. Schedule functionality may reside in a controller. If a controller is used, document scheduling functionality including names and types on controller points list submittal. Set up initial schedules in coordination with Owner.

F.   Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:
1.   Occupied Period: Period of time when the building is in use and occupied. Confirm schedule with Owner. Exclude all national holidays. Generally systems will be fully operational throughout this period and ventilation air to be continuously introduced. Space temperature setpoints will generally be in the "normal" range of 68 degrees to 78 degrees F.
2.   Unoccupied period: Period of time when the building or zone is not in use and unoccupied. Ventilation air not to be introduced.
3.   Preoccupancy Period: Time prior to the Occupied period when the systems are returning the space temperatures from setback to "normal" or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling or to support a pre-occupancy purge sequence. Time period to be determined by an optimum start strategy unless otherwise specified.
4.   Setback Period: Setback will typically start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a "setback" temperature, economization may be enabled to maintain "setback" cooling setpoint when applicable.

G.   Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands to be staggered by 5 second (adj.) intervals to minimize inrush current.

H.   Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

I.   When a power failure is detected in any phase, the BAS start commands to be retracted immediately from electrically powered units served by the failed power source. If the associated controller is powered by normal or emergency power, it may monitor its own power source as an indication of power status. If the controller is powered by uninterruptible power supply (UPS), or if it is not capable of monitoring its own power for use in sequences, provide at least one voltage monitor (three phase when applicable) per building. When the BAS detects that normal or emergency power has been restored, all equipment for which the BAS start command had been retracted to be automatically restarted in an orderly manner on staggered 5 second intervals to minimize inrush current.

J.   Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, employ one of the following methods:
1.   Determine a fixed reset schedule to result in stable operation and maintain the primary variable within the specified maximum allowable variance.
2.   Use a floating reset algorithm which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance.
3.   Primary variable to control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices to still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term to be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and settling time. Gain prior approval for implementing this method of reset.

K.   Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, employ the following method:
1.   Use a floating reset algorithm which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., space temperature) setpoint. The reset increment to be determined by the quantity of "need heat" or "need cool" requests from individual SCU's. A SCU's "need heat" virtual point to activate whenever the zone's space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU's "need cool" virtual point to activate whenever the zone's space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment to be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values to limit the setpoint range.

L.   Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method to be employed:

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1. A floating reset algorithm to be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g., cooling valve, heating valve, damper position) setpoint of 85 percent open. The reset increment to be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence to be chosen to maintain the primal variable within the specified maximum allowable variance while overshoot and settling time. The BAS analog output value to be acceptable as indicating the position of the control device.

2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the "need heat" or "need cool" virtual point to increment by one unit each time a zone's valve/damper position rises to greater than 95 percent. The quantity of "need heat" or "need cool" points to then be the basis for reset.

M. Where "prove operation" of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm to be enunciated audibly. Upon failure, run command to be removed and the device to be locked out until the alarm is manually acknowledged unless specified otherwise.

N. BAS to provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:
1. Speed control of variable speed drives
2. Control Reset Loop
3. Valve Travel Limit

O. Wherever a value is indicated to be dependent on another value (i.e., setpoint plus 5 degrees F) BAS to use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points to be provided. One to store the parameter (5 degrees F), one to store the setpoint, and one to store the value which is the result of the equation.

P. Trend points as identified in the points list. Trends to be grouped system specific and setup in two-axis (x,y) graphical format that display object values relative to time. Setup trends to record data in 5 minute increments.

Q. **Air Handling Unit (AHU-X), VAV HW/CHW 100 Percent Outside Air:**
1. General: Unit to operate under following modes: Occupied, Shutdown and Unoccupied. H-O-A switches on graphics screens or text dialog boxes may override on/off equipment.
2. Equipment:
   a. Air Handling Units: AHU-X
3. Occupied Mode:
   a. Occupied mode initiated from controller based on time of day or operator input. During occupied mode supply fan runs continuously.
   b. Normally closed outdoor air damper open.

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    c.   Normally closed fire smoke dampers in distribution ductwork open. Provide sufficient delay in fan start/stop to allow fire and smoke dampers to open/close without causing duct damage.

    d.   Discharge air temperature sensor signals controller which modulates in sequence normally open heating coil valve and normally closed cooling coil valve to maintain discharge air temperature setpoint of 55 degrees F as reset below.

    e.   Outdoor air and exhaust air temperature sensors signal controller.

    f.   Supply Air Temperature Setpoint Reset

        1)   When unit is enabled in occupied mode initially SAT setpoint set at 70 degrees F

        2)   If any zone has a cooling demand above 10 percent set the SAT setpoint at 62 (adj) degrees F (adj).

        3)   If the total number of zones with 100 percent cooling demand is greater than one reset the SAT setpoint down 1 degree F every five minutes (adj) to a minimum of 55 degrees F (adj).

        4)   If the total number zones with 100 percent cooling demand is zero, then reset SAT setpoint up 1 degrees F every five minutes (adj) to a maximum of 62 (adj) degrees F.

        5)   If the total number zones with a cooling demand greater than 10 percent is zero set the SAT setpoint at 70 degrees F (adj).

    g.   Remote duct static pressure sensors, as located on Drawings, signal controller which modulates supply fan variable frequency drive to maintain required static pressure setpoint at each location. Static pressure setpoints at each location continuously reset to maintain at least two terminal units with 100 percent damper position while maintaining space temperature setpoints.

    h.   Controller receives RPM signal from supply fan variable frequency drives.

4.   Shutdown Mode:

    a.   Supply fan is not operating.

    b.   Dampers and valves in their normal de-energized positions.

    c.   Fire and smoke dampers in distribution ductwork closed.

5.   Unoccupied Mode:

    a.   Night Setback and Setup: Supply fan operates when any space temperature drops to 60 degrees F or below or rises to 85 degrees F or above in designated zones. Maintain fan operation until space temperature rises to 63 degrees F (heating) or 82 degrees F (cooling). When supply fan operates, outdoor air dampers open, heating coil valve open (heating) or cooling coil valve open (cooling). Associated exhaust fans operate in conjunction with supply fan.

    b.   Unoccupied Mode Override: Upon receiving an "override" signal from designated space temperature sensors, controller changes building to occupied mode for period of 2 hours (adjustable). Coordinate location of designated sensors (quantity 2) with Owner.

    c.   In unoccupied mode, whenever supply fan operate, open fire smoke dampers in distribution ductwork. Provide sufficient delay in fan start/stop to allow fire and smoke dampers to open/close without causing duct damage. When supply fan operates in unoccupied mode, it operates as described for occupied mode.

6.   Alarms/Safeties:

    a.   Low limit detection thermostat located upstream of cooling coils signal controller which initiates shutdown mode upon sensing temperature below 38 degrees F and generate alarm.

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b. Differential pressure switches located across each filter bank generates an alarm when static pressure drop exceeds 0.75-inches for pre-filters and 1.2-inches for final filters.

c. Each variable frequency drive signals controller to generate alarm in event of drive/control failure.

d. Static pressure sensor in air handler discharge signals controller which overrides supply fan speed control algorithm to limit static pressure to maximum of 3-inches and generate alarm. Discharge static pressure sensor signals controller which shuts down mode in event that static pressure exceeds 4.0-inches and generate alarm.

R. **Combination Fire Smoke Dampers (FSD):**
1. Dampers closed upon receiving signal from fire alarm system, or from central controller.
2. Dampers closed when their corresponding fan is not operating.
3. Dampers open when fan systems are operating, unless overridden by fire alarm system.

S. **Variable Frequency Drives (VFD):**
1. Variable speed drives monitored by controller though LAN communications port on each drive. Reference Section 23 09 13. As a minimum, monitor the following points:
    a. Frequency output - Hz
    b. Speed - RPM
    c. Current - Amps
    d. Power - Percentage
    e. Runtime - Hours
    f. System Fault
    g. Input speed setpoint - RPM

T. Global Sequence of Operations
1. Include the following sequences in the BAS catalog of routines and execute when called upon by specific equipment. Mode of operation of units is initiated from BAS schedule.

U. Terminal Units with Hot Water Reheat (TU):
1. Occupied Mode
    a. Maintain space heating and cooling temperature setpoints by implementing the following routine, in sequence:
        1) If space temperature is higher than cooling temperature setpoint, disable terminal unit's heating system and maintain cooling temperature setpoint by modulating damper from Minimum airflow to Maximum Cooling airflow.
        2) If space temperature is less than heating temperature setpoint, initiate first stage of heating at Minimum Heating airflow and modulate heating coil's control valve(s), as applicable, to gradually increase unit's supply air temperature setpoint from 80 to 95 F.
        3) If space temperature is still less than heating temperature setpoint, confirm that the boiler plant is enabled and supply air temperature is above room setpoint and initiate second stage of heating by modulating damper from Minimum Heating airflow to Maximum Heating airflow while maintaining supply air temperature setpoint of 95 F.
        4) If space temperature is still less than occupied heating setpoint temperature, initiate third stage of heating by modulating heating coil's control valve.
    b. Standby Mode

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1) During occupied hours, for spaces without an occupancy sensor, enter Standby mode at the end of the Unoccupancy Override period if Unoccupancy Override switch has been activated, or when the Unoccupancy Override switch has been not activated by the occupant.

2) Initiate Standby mode if all normally occupied spaces served by the unit are provided with occupancy sensors.

3) Enter "Standby Mode" if the occupancy sensors in all rooms served by the terminal unit do not detect occupancy for 15 minutes (adj).

4) During Standby mode:

    a) Reset cooling temperature setpoint to 3 F (adj) above normal occupied setpoint and heating temperature setpoint to 3 F (adj) below normal occupied heating setpoint.

    b) After 30 minutes in Standby mode (adj), for a period of 15 minutes (adj) reset Minimum Heating CFM of the terminal unit to zero. At the end of 15 minute (adj) period, increase the Minimum outdoor air quantity setpoint of the air handling system by the Minimum Heating CFM of the zone.

    c) If the zone's occupancy sensors in all rooms served by the terminal unit do not detect occupancy for an additional 45 minutes (adj), or Unoccupancy Override switch has not been activated, for the next 15 minutes (adj) reset Minimum Heating CFM of the terminal unit to zero. Continue this routine until occupancy is detected, Unoccupancy Override switch has been activated, or there is a change in the mode of the system.

    d) When occupancy has been detected for 3 minutes (adj), or Unoccupancy Override switch has been activated, terminate Standby mode and reset all values to their original setpoints.

c. For zones with CO2 sensors, if space CO2 concentration is greater than 800 ppm (adj) modulate damper between Minimum Heating and Maximum Heating airflow setpoints to maintain maximum CO2 concentration of 900 ppm. Generate an alarm if the zone CO2 concentration is greater than 1,200 ppm (adj). Provide adequate delay (time determined during commissioning) to avoid false alarming and adequate time for system to balance during sudden loading of spaces.

2. Unoccupied Mode:

a. Close terminal unit damper and disable heating system. Ignore any signals from space occupancy or carbon dioxide sensors.

b. If space temperature is greater than unoccupied cooling temperature setpoint, and if central air handling unit is operating, modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

c. If space temperature is less than unoccupied heating temperature setpoint, modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 95 degrees F (adj.), as appropriate, to maintain space temperature at unoccupied heating setpoint.

d. During Unoccupied Mode, if any single zone falls below 40 F, generate an alarm and initiate Setback Mode until all zones are above 50 F.

3. Morning Warm-up Mode

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a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 90 degrees F to maintain space temperature setpoint corresponding to the appropriate mode.

4. Night Setback Mode
    a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 90 degrees F to maintain space temperature setpoint corresponding to the appropriate mode.

5. Morning Cool-down Mode:
    a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

6. Night Set-up Mode:
    a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

7. Night Purge Mode:
    a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

8. Pre-occupancy Purge Mode:
    a. One hour prior to occupancy operate the terminal unit at a minimum flowrate of 3 air changes per hour for all areas served by the unit and modulate terminal unit damper and HHW heating control valve, in sequence, to maintain corresponding cooling and heating temperature setpoints.

9. Unoccupied Override
    a. When an override signal from a space temperature sensor has been activated, change the mode of the terminal unit to Occupied for 2 hours (adj).
    b. Terminate Unoccupied Override mode when one of the following occurs:
        1) Timed override period of 2 hours (adj) has expired.
        2) Timed override is cancelled.

V. Terminal Units - Cooling Only (TU)
    1. Occupied Mode:
        a. Maintain space heating and cooling temperature setpoints by implementing the following routine, in sequence:
            1) If space temperature is higher than cooling temperature setpoint, maintain cooling temperature setpoint by modulating damper from Minimum airflow to Maximum airflow.
    2. Standby Mode
        a. During occupied hours, for spaces without an occupancy sensor, enter Standby mode at the end of the Unoccupancy Override period if Unoccupancy Override switch has been activated, or when the Unoccupancy Override switch has been not activated by the occupant.
        b. Initiate Standby mode if all normally occupied spaces served by the unit are provided with occupancy sensors.
        c. Enter "Standby Mode" if the occupancy sensors in all rooms served by the terminal unit do not detect occupancy for 15 minutes (adj).
        d. During Standby mode:

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1) Reset cooling temperature setpoint to 3 F (adj) above normal occupied setpoint and heating temperature setpoint to 3 F (adj) below normal occupied heating setpoint.

2) After 30 minutes (adj) in Standby mode, for a period of 15 minutes (adj) reset Minimum CFM of the terminal unit to zero. At the end of 15 minute (adj) period, increase the Minimum outdoor air quantity setpoint of the air handling system by the Minimum CFM of the zone.

3) If the zone's occupancy sensors in all rooms served by the terminal unit do not detect occupancy for an additional 45 minutes (adj), or Unoccupancy Override switch has not been activated, for the next 15 minutes (adj) reset Minimum CFM of the terminal unit to zero. Continue this routine until occupancy is detected, Unoccupancy Override switch has been activated, or there is a change in the mode of the system.

4) When occupancy has been detected for 3 minutes (adj), or Unoccupancy Override switch has been activated, terminate Standby mode and reset all values to their original setpoints.

3. For zones with CO2 sensors, if space CO2 concentration is greater than 800 ppm (adj) modulate damper between Minimum and Maximum airflow setpoints to maintain maximum CO2 concentration of 900 ppm. Generate an alarm if the zone CO2 concentration is greater than 1,200 ppm (adj). Provide adequate time delay, to be determined in cooperation with the test and balance agent, to avoid false alarms and adequate time for system to balance during sudden loading of space.

4. Unoccupied Mode:
   a. Close terminal unit damper. Ignore signals from space occupancy or carbon dioxide sensors.
   b. If space temperature is greater than unoccupied cooling temperature setpoint, and if central air handling unit is running, modulate damper between no airflow and Maximum Cooling airflow to maintain space temperature at unoccupied cooling temperature setpoint.
   c. If space temperature is less than unoccupied heating temperature setpoint, close damper.
   d. During Unoccupied Mode, if any single zone falls below 40 F, generate an alarm and initiate Setback Mode until all zones are above 50 F.

5. Morning Warm-up or Night Setback Mode
   a. Modulate damper between no airflow and Maximum Heating airflow setpoints, in sequence with modulating heating coil's control valve subject to a maximum discharge air temperature of 95 degrees F (adj.), as appropriate, to maintain space temperature setpoint corresponding to the appropriate mode.

6. Morning Cool-down Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

7. Night Set-up Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

8. Night Purge Mode:
   a. Modulate damper between no airflow and Maximum Cooling airflow setpoints to maintain space temperature at unoccupied cooling temperature setpoint.

9. Pre-occupancy Purge Mode:

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a. One hour prior to occupancy operate the terminal unit at a constant airflow rate of 3 air changes per hour for all areas served by the unit and modulate terminal unit damper to maintain corresponding cooling temperature setpoint.

10. Unoccupied Override

a. When an override signal from a space temperature sensor has been activated, change the mode of the terminal unit to Occupied for 2 hours (adj).

b. Terminate Unoccupied Override mode when one of the following occurs:

1) Timed override period of 2 hours (adj) has expired.

2) Timed override is cancelled.

W. Variable Volume Exhaust Fan

1. Enable fans at all times unless shutdown on safeties.

2. Fan Control:

a. Shutdown Service Switch: Provide a software point and hardware switch located inside the control panel for fan to be taken out of service that will initiate the shutdown sequence for the fan.

b. Exhaust Fan Start/Stop Sequencing: Sequence fans on, based on exhaust fan flow. If a fan has failed or has been designated "out of service" per the sequence below, shut down associated Air handler.

c. Maintain a minimum exhaust discharge velocity of 3,000 fpm, or as otherwise indicated on drawings, by maintaining a minimum flow. Prevent the exhaust fan from falling below this minimum speed to prevent the discharge velocity from falling below design. Determine minimum fan speed required to maintain minimum flow setpoints in cooperation with the test and balance agent.

3. Static Pressure Control:

a. Exhaust Fan Speed Control: Maintain a minimum static pressure in the exhaust ductwork. Install static pressure sensing probes in the main exhaust duct located at approximately 3/4 of the way down the main exhaust duct or as shown on the plans. Reference input for duct static pressure sensors shall sense the actual space served by the air system located in the ceiling below the duct probe. Modulate the exhaust fan VFDs to maintain the static pressure setpoint as sensed by the static pressure probe(s). As exhaust airflow requirements decrease and the static pressure becomes more negative than setpoint, decrease the exhaust fan VFD speed signals simultaneously and in parallel to maintain the static pressure setpoint until the minimum fan flow setpoint is reached.

b. As exhaust airflow requirements increase and duct static pressure becomes less negative than setpoint, operate fan(s) at minimum fan flow setpoints.

4. Generate alarms as follows:

a. Low Stack Velocity: If stack nozzle discharge velocity with corresponding pressure drops below 3000 FPM (adj).

b. Exhaust fan failure: Commanded on, but the status is off.

c. Exhaust fan operating in Hand mode: Commanded off, but the status is on.

d. High Exhaust Air Static Pressure: If the exhaust air duct static pressure is 25 percent (adj.) greater than setpoint.

e. Low Exhaust Air Static Pressure: If the exhaust air duct static pressure is 25 percent (adj.) less than setpoint.

W. Variable Volume Laboratory Exhaust Fan - EF-AP1

1. Enable fan at all times unless shutdown on safeties.

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2. **Fan Control**
   a. **Exhaust Fan Start/Stop Sequencing: Sequence fans on, based on exhaust fan flow and outside air bypass damper position in the order designated by the Fan Selection sequence.**
   b. **Maintain a minimum exhaust discharge velocity of 3,000 fpm, or as otherwise indicated on drawings, by maintaining a minimum flow. Prevent the exhaust fan from falling below this minimum speed to prevent the discharge velocity from falling below design. Determine minimum fan speed required to maintain minimum flow setpoints in cooperation with the test and balance agent.**
3. **Static Pressure Control**
   a. **Exhaust Fan Speed Control: Maintain a minimum static pressure in the exhaust ductwork. Install static pressure sensing probes in the main exhaust duct located at approximately 3/4 of the way down the main exhaust duct or as shown on the plans. Reference input for duct static pressure sensor shall sense the actual space served by the air system located in the ceiling below the duct probe. Modulate the exhaust fan VFDs and outside air bypass damper in sequence to maintain the static pressure setpoint as sensed by the static pressure probe. As exhaust airflow requirements decrease and the static pressure becomes more negative than setpoint, decrease the exhaust fans VFD speed signals simultaneously and in parallel to maintain the static pressure setpoint until the minimum fan flow setpoint is reached. If the static pressure continues to fall, modulate open the outside air bypass damper to maintain the static pressure setpoint.**
   b. **As exhaust airflow requirements increase and duct static pressure becomes less negative than setpoint, operate fan at minimum fan flow setpoints and gradually close the outside air bypass damper to maintain duct static setpoint. When the outside air bypass dampers are fully closed, gradually increase exhaust fan speed to maintain duct static pressure setpoint.**
4. **Generate alarms as follows:**
   a. **Low Stack Velocity: If stack nozzle discharge velocity with corresponding pressure drops below 3000 FPM (adj).**
   b. **Exhaust fan failure: Commanded on, but the status is off.**
   c. **Exhaust fan operating in Hand mode: Commanded off, but the status is on.**
   d. **Exhaust fan runtime Exceeded: Status runtime exceeds a user definable limit.**
   e. **VFD Fault.**
   f. **High Exhaust Air Static Pressure: If the exhaust air duct static pressure is 25 percent (adj.) greater than setpoint.**
   g. **Low Exhaust Air Static Pressure: If the exhaust air duct static pressure is 25 percent (adj.) less than setpoint.**
   h. **Bypass damper fault.**

END OF SECTION

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