BID DOCUMENTS COVER SHEET

CONTRACT DOCUMENTS

FOR

L-1201 Science Building BAS Upgrade

AT

Los Medanos College

2700 East Leland Road, Pittsburg, CA 94565

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

Consists of the following:

VOLUME 1
SPECIFICATIONS

March 31, 2022

SECTION 00010

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VOLUME 1

SPECIFICATIONS

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

DIVISION 01 – GENERAL REQUIREMENTS

See SECTION 00800 SUPPLEMENTARY GENERAL CONDITIONS

TECHNICAL SPECIFICATIONS

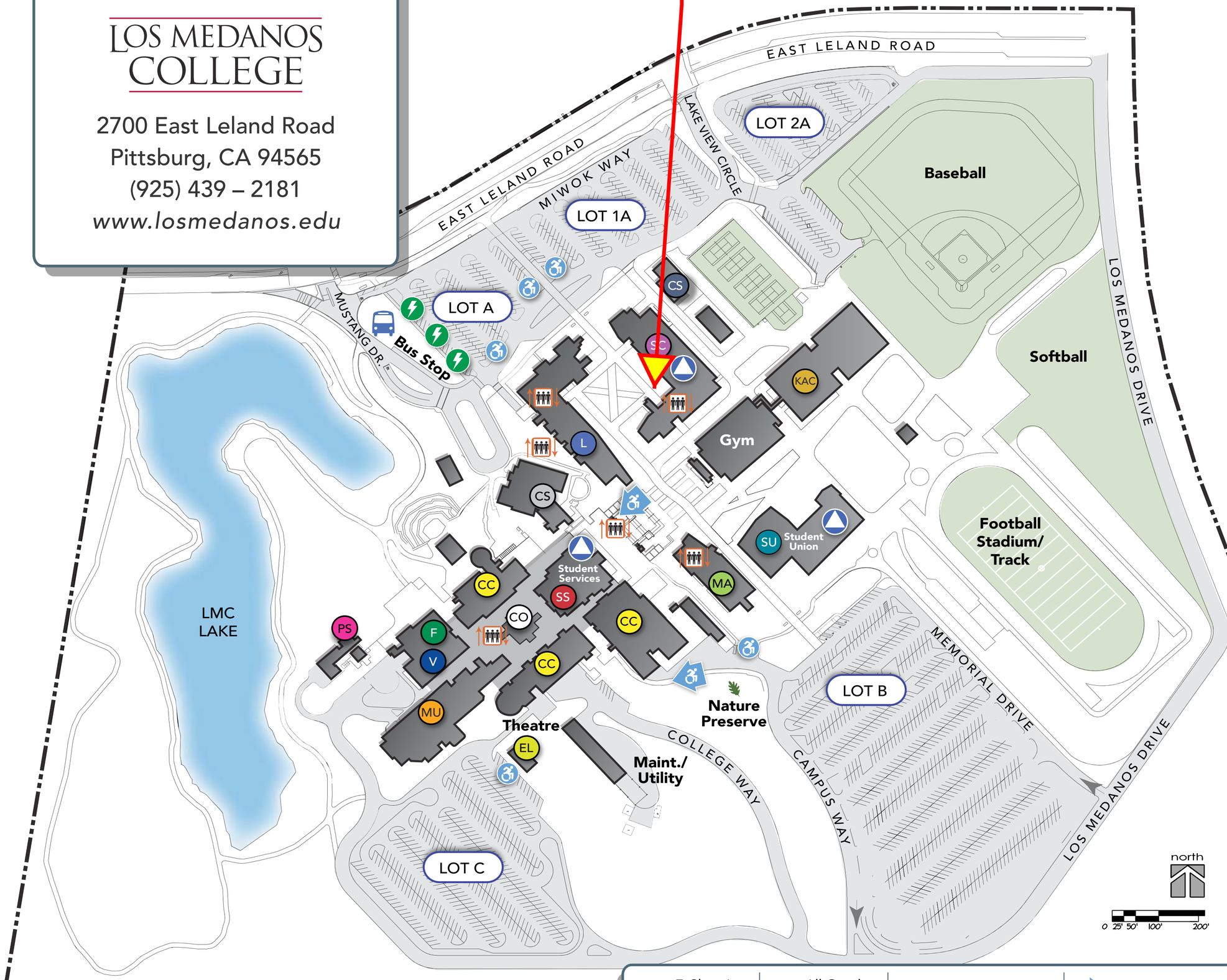
END OF SECTION

Campus Overview

LOS MEDANOS COLLEGE

2700 East Leland Road
Pittsburg, CA 94565
(925) 439 – 2181
www.losmedanos.edu

Pre-bid Meeting Location - Outside of Science Building



Building Legend

- CC — College Complex
- CO — CORE
  - Business Services
  - Center for Academic Support
  - Equity & Inclusion
- CS — Child Study Center
- CS — Campus Safety
  - Police Services
- EL — ETEC Lab
- F — Cafeteria
- KAC — Kinesiology & Athletics Complex
- L — Library
  - Community Room
- MA — Math
- MU — Music
  - Recital Hall
- PS — Classrooms
- SC — Science
  - MESA Center
- SS — Student Services
  - Admissions/Cashier
  - Assessment Services
  - Counseling Services
  - DSPS
  - EOPS, CARE, CalWORKs
  - Financial Aid/Scholarships
  - Information/Welcome Center
  - LMC Foundation
  - Office of Instruction
  - President's Office
  - Transfer & Career Services
- SU — Student Union
  - Bookstore
  - Conference Center
  - Food Pantry
  - Honors Program
  - International Students Program
  - Latinx Empowerment Center
  - Reflection Room
  - Student Life
  - Student Lounge
  - Unity Center
  - Umoja Scholars Program
- V — Veterans Resouce Center

E-Charging Stations | All Gender Restrooms | Accessible Parking | Accessible Entrance | Bus Stop | Elevator

Smoking restricted to parking lot areas.

SECTION 00100
NOTICE INVITING BIDS

L-1201 SCIENCE BUILDING BAS UPGRADE

LOS MEDANOS COLLEGE
2700 E Leland Rd.
Pittsburg, CA 94565

NOTICE IS HEREBY GIVEN that the Governing Board of the Contra Costa Community College District (District), Martinez, California, will receive sealed bid proposals for the furnishing of all labor, materials, equipment, transportation and services for the construction of the project entitled **L-1201 Science Building BAS Upgrade.**

Construction Cost Estimate (Range): **$450,000 to $475,000**

California License Required: **B General or C-20 Warm Air Heating, Ventilating and Air Conditioning**

SCOPE OF WORK: The scope of work includes, but not limited to the following:

- Replacing the existing Andover direct digital control (DDC) systems and Triatek air valves at Los Medanos Science Building with a new ALC Building Automation System (BAS) and AccuValve air valves.

The District does not provide hardcopies of bid documents or reimburse cost of printing, delivery, or any expenses related to the bidding process.

For information directly from the District, you may also log on to the District Website: https://webapps.4cd.edu/apps/purchasingviewbids/default.aspx. Project documents available include, but are not limited to, plans, specifications, addenda, bidders lists, bid results, etc., and can be viewed on this District webpage. Builders Exchanges around Northern California are also notified.

All questions related to this project must be submitted electronically, *no later than* Thursday, April 14, 2022, prior to 2:00 PM to:

Ben M. Cayabyab, Contracts Manager
Contra Costa Community College District
Email: bcayabyab@4cd.edu

Each bid shall be made on the Bid Proposal Form, which is included in the Bid Documents and when submitted, shall be accompanied by a Bid Bond or Certified Cashier's Check in the amount of 10% of bid (made payable to the Contra Costa Community College District). The District reserves the right to forfeit Bid Bond submitted for failure of the successful bidder to secure Payment & Performance Bonds.

IMPORTANT INFORMATION:
PLEASE NOTE: A Site Visit will be held immediately following the Pre-Bid meeting. Please sign in on the attendance Log. Attendees are required to wear face masks, as required by CCC Health Services.

Pre-Bid Meeting and Job Walk, Date/Time: ..... Tuesday, April 12, 2022 at 2:00 PM (**Mandatory**)
Pre-Bid Meeting Location: ..... Los Medanos College – 2700 E. Leland Road, Pittsburg, CA

94565
Last Date / Time for Bidder's
Requests for Information: ..... **Thursday, April 14, 2022 (prior to 2:00pm)**

Bids Due No Later Than, Date / Time: ..... **Thursday, April 28, 2022 (prior to 2:00pm)**

Bids Must Be Received at: ..... **Contra Costa Community College District (Lobby)**
500 Court St, Martinez, CA 94553
Attn: Ben M. Cayabyab, Contracts Manager

Bids must be received by the District prior to the time and by the date noted above. Bids that are not received by the District prior to the time and by the date noted above will not be accepted, and will be returned to the Bidder, unopened. The District is not responsible for lost or misplaced proposals delivered by a 3rd party carrier.

The successful bidder will be required to furnish a labor and material bond in an amount equal to one hundred percent (100%) of the contract price and a faithful performance bond in an amount equal to one hundred percent (100%) of the contract price, said bonds to be secured from a surety company acceptable to the Contra Costa Community College District and authorized to execute such surety in the State of California. Certificates of Liability Insurance with proper endorsements shall be required for the successful bidder.

This project is a public works project and is subject to prevailing wage rate laws. A copy of the prevailing rates of wages is on file with the Contracts & Purchasing Office of the Contra Costa Community College District, available at the DIR website at https://www.dir.ca.gov/oprl/pwappwage/PWAppWageStart.asp. Said rates of wages shall be included in the contract for the work by this reference.

Attention is directed to Section 4100 through 4113 of the Public Contract Code concerning Subcontractors, with emphasis on Section 4104, known as the "Subletting and Subcontracting Fair Practices Act, effective July 1, 2014".

Attention is directed to Labor Code Section 1725.5 regarding Department of Industrial Relations (DIR) contractor registration process including registration criteria and implementation of DIR registration requirements. Labor Code Section 1771.7 establishes contractor's obligation to submit Certified Pay Roll (CPR) to the Department of Labor and Standards Enforcement (DLSE) and public works monitoring and enforcement. Labor Code Section 1773.3 requires the District to submit a PWC-100 to DIR for all public works contract awarded effective January 1, 2015.

Failure to submit all of the above may cause your bid to be non-responsive and disqualified for contract award.

The contract time is **124 Calendar Days** between the Notice to Proceed date and the Contract Substantial Completion date. Attention is directed to Section 00600, Construction Agreement, Article 5, regarding liquidated damages. Liquidated Damages shall be set for **One Thousand Dollars ($1,000)** for each Calendar Day the Work is delayed beyond the contract Substantial Completion date; and **Five Hundred Dollars ($500)** for each Calendar Day Remaining Work is delayed beyond the Contract Final Completion Date. The Governing Board of the Contra Costa Community College District reserves the right to reject any and all bids and/or waive any informality or irregularity in any bid received. No bidder may withdraw their Bid for a period of ninety (90) days after the date set for opening thereof.

END OF SECTION

SECTION 00200

INSTRUCTIONS TO BIDDERS

1.1 ISSUING OF DOCUMENTS

Bidding Documents may be examined on the District's Open Solicitations web page, https://webapps.4cd.edu/apps/purchasingviewbids/default.aspx, ~~and at the Contra Costa Community College District, 500 Court Street, Martinez, CA 94553, by appointment only: Georgette Stewart, Facilities Department, phone (925) 229-6847.~~

1.2 QUALIFICATIONS OF BIDDERS

A. Bidders may be required to furnish evidence satisfactory to the District and the Architect that he has sufficient means and has had sufficient experience in the class of work called for to enable him to complete the Contract in a satisfactory manner.

B. Bidders shall be Contractors properly licensed in accordance with the laws of the State of California.

C. The successful Bidder shall furnish satisfactory Certificates of Insurance coverage as specified in the Contract Documents.

1.3 RECEIPT AND OPENING OF BIDS

A. Contra Costa Community College District hereinafter referred to as the District, will receive Bids at the same time and place specified in the Notice inviting Bids.

B. Complete the Bid Proposal Form included in the Project Manual.

C. The envelopes containing the Bids shall be sealed, addressed to the District, and designated as ***"L-1201 Science Building BAS Upgrade, Contra Costa Community College District"***. The envelope shall contain the name and address of the Bidder.

D. Bids that are mailed shall have the previously described envelope placed inside an envelope addressed to: **CONTRA COSTA COMMUNITY COLLEGE DISTRICT, 500 Court Street, Martinez, CA 94553, ATTENTION: Ben Cayabyab, Contracts Manager**. Bids should be mailed in time to be received prior to the time set forth in the Notice inviting Bids.

E. Bids which are conditional (or which make alterations, omissions, or reservations to the terms of the Bidding Documents) may be rejected as non-responsive.

F. All monetary figures are required, both in writing and in numerals. In event of conflict between written quotations and numerical quotations, written quotations shall govern.

G. Type or print all bid data legibly in ink except signatures which shall be in script. Mistakes may be crossed out and corrections inserted, if each is initialed in ink by signer of Bid.

H. Bidder's business address and signature shall be on the Bid. A Bid by a partnership shall furnish the full names of partners and be signed in the partnership name by one member of the partnership, or by authorized representative, followed by the signature and designation of the person signing. Bids by corporations, with corporate seal affixed, shall be signed with the legal name of the corporation followed by the name of the state of incorporation and by the signature and designation of the person authorized to bind it to the matter. The name of each person signing shall also be typed or printed below the respective signatures. When required by the District,

satisfactory evidence of authority of the office signing on behalf of the corporation shall be furnished.

I. No Bids will be received after the date and time set forth in the Notice Inviting Bids.

1.4 BID SECURITY

A. Submit with the Bid a Bid Security in the amount of 10 percent (10%) of the Bid.

B. The District reserves the right to forfeit the Bid Bond submitted for failure of the successful bidder to secure Payment & Performance Bonds.

1.5 SURETY BONDS

A. The successful Bidder shall furnish a Labor and Material Payment Bond in the amount equal to one hundred percent (100%) of the Contract Price and a faithful Performance Bond in the amount equal to 100 percent (100%) of the Contract Price as security for the successful performance of the work and payment of persons performing labor and furnishing materials. The Bonds shall be executed by a surety company or companies acceptable to the District and authorized to execute such in the State in which the Project is located and shall be furnished within 10 days after Notice of Acceptance of said Bid. Surety shall be made in favor of the District and shall cover the guarantee periods as well as the construction period.

1.6 WITHDRAWAL OR REVISIONS OF BID

A. This Bid may be withdrawn or revised prior to the scheduled time for receipt. Bids not withdrawn prior to the scheduled time for receipt may not be withdrawn for a period of 90 days.

1.7 BID PROTESTS

A. Inquiries or questions based on alleged patent ambiguity of the plans, specifications or estimate must be communicated as a bidder inquiry prior to bid opening. Any such inquiries or questions, submitted after bid opening, will not be treated as a bid protest.

B. Bidder may file a protest with the District against the Bid of other Bidder or Bidders ("Bid Protest") subject to the provisions of this Article. The procedures and time limits set forth in this Article are mandatory and are a Bidder's sole and exclusive remedy in protesting other Bidders' bids. Failure to comply with these procedures shall constitute a waiver of any right to pursue a Bid Protest, or to contest the District's award of the contract for the work that is the subject of the Bid, in any legal proceeding before any authority with jurisdiction.

C. Bid Protests and Responses shall be governed by the following time limitations:

1. Bidder must deliver any Bid Protest to the District in writing before 2:00PM, five (5) working days after the date of bid opening. The District will reject any Bid Protest not received by the District by this deadline. Bidder must concurrently deliver a copy of its Bid Protest to all Bidders against whose Bids the Bid Protest is directed. The Bidder must include with its Bid Protest written proof to the District's satisfaction that Bidder has delivered a copy of its Bid Protest to the other Bidder whose bid is the subject of the Bid Protest.

2. A Bidder whose Bid is the subject of a Bid Protest must deliver its written response, if any, ("Response") to the District, before 2:00PM, five (5) working days after the date of bid opening. The District will reject any Response not received by the District by this deadline.

D. Delivery of Bid Protest or Response:

1. Bidder may deliver a Bid Protest to the District by personal delivery or electronic transmission such as by facsimile. Bidder is solely responsible for ensuring that the District receives any Bid Protest or Response by the deadlines set forth herein.
2. The District will not consider Bid Protests or Responses by telephone conversation or any other non-written communication.
3. Bidder shall submit any Bid Protest or Response to: Amy Sterry, Director of Purchasing and Contract Services, Contra Costa Community College District, 500 Court Street, Martinez, CA 94553, Facsimile: 925-370-7512.

E. Content of Bid Protest:

1. A Bid Protest must state the basis for the protest and provide supporting evidence.
2. A Bid Protest must refer to the specific portion of the Bid that forms the basis of the protest.
3. A Bid Protest must include the name, address, and telephone number of the person representing the protesting Bidder.
4. A Bid Protest must be clearly identified as a Bid Protest.

1.8 AWARD AND REJECTION OF BIDS

A. In awarding or rejecting Bids, the District reserves the following rights:

1. Identification of successful Bidder will not be determined at time of opening Bids.
2. To obtain opinion of counsel on legality and sufficiency of bids.
3. To reject all Bids, to re-bid, or waive irregularities or informalities in a Bid, and to accept or reject alternates.
4. Request proof that the successful Bidder can provide performance and payment bonds as required.

1.9 EXAMINE DOCUMENTS AND VISIT SITE

A. Before submitting a Bid, the Bidder shall examine the Bidding Documents, visit the site of the work, attend the required site visit arranged by the District and obtain Certification of Attendance signed by the District, ascertain existing conditions and limitations, including those of labor, and include in the Bid a sum to cover the cost of all items described in the Contract Documents.

B. No consideration will be granted for alleged misunderstanding of the materials to be furnished or work to be done. The tender of a Bid carries with it the agreement to terms and conditions referred to in the Contract Documents.

1.10 DISCREPANCIES, AMBIGUITIES, OR CONFLICTS

A. If the Bidder is in doubt as to the true meaning of any part of the Contract Documents; finds discrepancies, errors or omissions therein; or finds variances in any of the Contract Documents with applicable rules, regulations, ordinances and/or laws, a written request for an interpretation or correction thereof must be submitted to the District's Contract Manager. Bidders are solely responsible for submitting to District's Contract Manager such request. Ambiguities or inconsistencies arising as a result of separation of sections or portions of the drawings or specifications by or for subcontractor bidding shall not relieve the Contractor for providing the complete Work without increase to or adjustment in the Contract Price or the Time for performance. Interpretations or corrections of the Contract Documents will be by written addendum issued by the Architect. No person is authorized to render an oral interpretation or

correction of any portion of the Contract Documents to any Bidder, and no Bidder is authorized to rely on any such oral interpretation or correction. Failure to request interpretation or clarification of any portion of the Contract Documents pursuant to the foregoing is a waiver of any discrepancy, defect or conflict therein.

1.11 ADDENDA

A. Cost for work included in any Addenda issued during the time of bidding shall be included in the Bid, and will become a part of the Contract. List Addenda received as indicated on the Bid Form.

1.12 FORM OF AGREEMENT

A. The form of agreement to be used for the Contract is provided by the District and is included in the Project Manual.

1.13 AWARD OF CONTRACT

A. The District will be allowed a period of ninety (90) days after Bid Opening Date for evaluating the Bids.

B. Bidders of record will be notified of the results of the District's evaluation of bids and Award of Contract, if any.

C. The contractor shall begin work within ten (10) calendar days of receipt of Notice to Proceed.

END OF SECTION 00200

SECTION 00210

INFORMATION AVAILABLE TO BIDDERS

PART 1 - REPORT AND INFORMATION

1.1 Existence of reports, record drawings, and utility surveys**:** Contra Costa Community College District, its consultants, and prior contractors may have collected documents providing a general description of the site and conditions of the work. These documents may consist of geotechnical reports for and around the site, record drawings, utility drawings, and information regarding underground utilities. These reports, documents and other information are not part of the Contract Documents and do not show new work to be constructed, rather, they show existing conditions that Contractor may have to address as part of its construction planning.

1.2 Available Documentation: The following existing documentation has been made available for downloading via the District's web site:
https://webapps.4cd.edu/apps/purchasingviewbids/default.aspx

A. Project documents titled:

1. "26-05 - Science Building Andover Submittal Drawings Rev A"
2. "26-05 - Science Building Architectural As-Built Drawings"
3. "26-05 - Science Building Electrical, Fire Alarm, Telecom As-Built Drawings"
4. "26-05 - Science Building Lab Furnishing & Piping As-Built Drawings"
5. "26-05 - Science Building Mechanical As-Built Drawings"
6. "26-05 - Science Building Plumbing As-Built Drawings"
7. "26-05 - Science Building Triatek Fume Hood Diagrams"
8. "LMC Room Numbers and Fume Hood Locations"
9. "sci.chiller.bcx1.dmp"
10. "science.dmp"
11. "science.labs.dmp"
12. "Triatek Zone Presence Sensor Installation Manual"

1.3 Contractor shall acknowledge and accept that the documents are not a part of the Contract Documents and are made available to bidders for reference only. The District and its representatives are not responsible for any and all discrepancies between the documents and the existing and actual as-built conditions, and do not guarantee the accuracy of the documents.

1.4 The District and Design Consultants assume no responsibility for the completeness or accuracy of the documents or the records compiled there from and the interpretations made from the documents. There is no express or implied guarantee that the conditions indicated in the documents are representative of those existing throughout the building and/or site Conditions differing substantially from those indicated may be encountered.

END OF SECTION 00210

SECTION 00300
BID PROPOSAL FORM

PROJECT NUMBER / NAME: L- 1201 Science Building BAS Upgrade

CAMPUS / LOCATION: Los Medanos College, 2700 E Leland Rd, Pittsburg, CA 94565

DISTRICT: CONTRA COSTA COMMUNITY COLLEGE DISTRICT
500 Court St, Martinez, CA 94553

Herein Referred to as "District"

1. INTRODUCTION

A. The Bidder proposes to perform the Work for the Contract Sum and within the proposed Contract Time, based upon an examination of the site and the Bid and Contract Documents.

B. The Bidder certifies this Bid is submitted in good faith.

C. The Bidder agrees that the Contract Sum and other proposed terms will be considered in evaluating Bids and may be negotiated and adjusted before awarding of Contract.

D. The signed copy of the Certification of the Visit to the Site shall be attached to the Bid Form Submittal.

E. A fully executed Statement of Bidder's Qualifications signed by an authorized officer of the Bidder submitting the Bid shall be attached to the Bid Form.

F. A fully executed Non-Collusion Affidavit signed by an authorized officer of the Bidder submitting Bid shall be attached to the Bid Form.

G. The District shall award the contract to the lowest responsive and responsible Bidder. The evaluation of the low bid shall be based on the total of Item 2.A Base Bid, 2.B Unit Price, and all listed Add Alternates 3.1 through 3.8.

H. The District reserves the right to delete any or all Add Alternates, if any, through change orders within **25 calendar days** after the Award of Contract. If deleted by the District, the deleted dollar amount shall be the amount listed for the specific Add Alternate. The Contract Time will remain the same regardless if any Add Alternate is deleted.

2. CONTRACT SUM

A. BASE BID
For labor, materials, bonds, fixtures, equipment, tools, transportation, services, sales taxes, overhead and profit, and other costs necessary to complete the general construction in accordance with the Contract Documents, for a stipulated Contract Sum in the amount of:

_____Dollars ($_____)

B. UNIT PRICES

When estimated quantities as noted below, are exceeded, the Contractor will be compensated per the unit prices listed below. Contractor shall honor the unit price even when the quantities go beyond what is shown below. Should these unit costs not be required a deductive change order will be issued.

Unit prices include labor, materials, bonds, fixtures, equipment, tools, transportation, services, sales taxes, overhead and profit, and other costs necessary to complete the general construction in accordance with the Contract Documents, for a stipulated Contract Sum in the amount of:

1. Unit Price #1: VAV Box Calibration Unit Price (per VAV Box)
(SEE SPECIFICATION SECTION 250000 BUILDING AUTOMATION SYSTEM SUBSECTION 1.2.H.9 FOR FULL DESCRIPTION OF SCOPE FOR UNIT PRICE)

Qty: 3 x $_____

SUBTOTAL $_____

3. ADD ALTERNATES

(SEE SPECIFICATION SECTION 250000 BUILDING AUTOMATION SYSTEM SUBSECTION 1.2.H FOR FULL DESCRIPTION OF SCOPE FOR ADD ALTERNATES)

1. **ARCNet for Primary LAN.**

Dollars ($)

2. **Onsite Virtual Server**

Dollars ($)

3. **VFD Integration**

Dollars ($)

4. **Reuse VAV and Lab Zone Reheat Coil Valves**

Dollars ($)

5. **Add DCW Multi-Jet Flow Meters**

Dollars ($)

6. **Add DCW Magnetic Flow Meters**

Dollars ($)

7. **Add Natural Gas Meter**

_____ Dollars ($ _____)

8. **No CAD Files**

_____ Dollars ($ _____)

4. COMPLETION TIME

A. For establishing the Date of Final Completion, the contract time for the Base Bid shall be as indicated in Section 00600, Construction Agreement. This time may be subject to modification to facilitate the work, as mutually agreed upon at a later date.

B. The Bidder certifies that the Bid is based on the Contract Time for completion as stated in Section 00600, Construction Agreement. Bidder further certifies that the Base Bid amount is sufficient to cover all labor, materials, central office and construction site overhead, profit, and all other costs related to the completion of the Project for the entire Project construction time for both the General Contractor and all Subcontractors, as stated above in paragraphs 2 and 3.

5. ADDENDA

A. The Bidder acknowledges receipt of the following Addenda, and certifies the Bid has provided for all modifications and considerations required therein.

None [ ]

Addendum No.: _____ dated _____

Addendum No.: _____ dated _____

Addendum No.: _____ dated _____

Addendum No.: _____ dated _____

B. List of Additional Addenda Attached: Yes [ ] No. [ ].

6. DESIGNATION OF SUBCONTRACTORS

A. The Bidder has set forth a complete list indicating the type of work, name, and business address of each Subcontractor who will perform work in excess of one-half of one percent of the Contract Sum.

B. Any portion of the work in excess of the specified amount having no designated Subcontractor shall be performed by the Bidder.

C. Substitution of listed Subcontractors will not be permitted unless approved in advance by the District.

D. Prior to signing the Contract, the District reserves the right to reject any listed Subcontractor.

	Type of Work	Subcontractor's Name	Business Address/Phone	CSLB License # and DIR Registration #
1				
2				
3				

E. Complete list of Subcontractors is attached: Yes [ ] No [ ]

F. Continuation list of Subcontractors is attached: Yes [ ] No [ ]

7. ACCEPTANCE AND AWARD

A. The District reserves the right to reject this Bid and to negotiate changes before or after execution of the Contract. This Bid shall remain open and shall not be withdrawn for a period of 90 days after Bid Opening date.

B. If written notice of acceptance of this Bid is mailed or delivered to the Bidder within 90 days after the date set for the receipt of this Bid, or other time before it is withdrawn, the Bidder will execute and deliver to the District a Contract prepared by District with the required Surety Bonds and Certificates of Insurance, within 10 days after personal delivery or deposit in the mail of the notification of acceptance.

C. Notice of acceptance or request for additional information may be addressed to the Bidder at the address provided.

8. BID SECURITY

A. The required 10 percent (10%) Bid Security for this Bid is attached in the form of:

( ) Bid Bond Issued By: _____

( ) Certified or Cashier's Check No._____

Issued by: _____

9. BIDDER'S BUSINESS INFORMATION

A. Individual [ ]: _____

Personal Name: _____

Business Name: _____

Address: _____

_____ Zip Code: _____

Telephone: _____

Fax Number: _____

B. Partnership [ ]: _____

Co-partners' Names: _____

Business Name: _____

Address: _____

_____ Zip Code: _____

Telephone: _____

Fax Number: _____

C. Corporation [ ]: _____

Firm Name: _____

Address: _____

_____ Zip Code: _____

Telephone: _____

Fax Number: _____

State of Incorporation: _____

President: _____

Secretary: _____

Treasurer: _____

Manager: _____

D. Power of Attorney: Name: _____

Title: _____

E. Contractor License No. _____ State of _____

F. Bidder is submitting this proposal on behalf of a Joint Venture. Names, license numbers, and relevant information are given on a separate attachment:
Yes [ ] No [ ].

G. Upon request, furnish appropriate documentation to substantiate and/or support the data given.

10. The undersigned hereby certifies under penalty of perjury under the laws of the State of California that all the information submitted by the Bidder in connection with this Bid and all the representations herein made are true and correct.

Executed this day of _____

_____

CSLB License No. Expiration Date DIR Registration No.

_____

Firm Name

_____

Signature

_____

By (Print or Type Name)

_____

Title

End of Section 00300

NONCOLLUSION AFFIDAVIT
(TO BE EXECUTED BY BIDDER AND SUBMITTED WITH BID)

State of California

County of Contra Costa

_____, being first duly sworn, deposes and says that he or she is of _____, the party making the foregoing bid that the bid is not made in the interest of, or on behalf of, any undisclosed person, partnership, company, association, organization, or corporation; that the bid is genuine and not collusive or sham; that the bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham bid, and has not directly or indirectly colluded, conspired, connived, or agreed with any bidder or anyone else to put in a sham bid, or that anyone shall refrain from bidding; that the bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the bid price of the bidder or any other bidder, or to fix any overhead, profit, or cost element of the bid price, or of that of any other bidder, or to secure any advantage against the public body awarding the contract of anyone interested in the proposed contract; that all statements contained in the bid are true; and, further, that the bidder has not, directly or indirectly, submitted his or her bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, or paid, and will not pay, any fee to any corporation, partnership, company association, organization, bid depository, or to any member or agent thereof to effectuate a collusive or sham bid.

I certify (or declare) under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Date: _____ Signature: _____

State of California
County of Contra Costa

On _____, before me, _____, Notary Public , personally appeared

_____, personally known to me (or proved to me on the basis of satisfactory evidence) to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing is true and correct.

WITNESS my hand and official seal.

Date: _____ Signature: _____

[SEAL]

END OF SECTION 00350

SECTION 00450

CERTIFICATION OF SITE VISIT

The Governing Board of the
Contra Costa Community College District
500 Court Street
Martinez, California 94553

Gentlemen/Ladies:

I visited the **L-1201 Science Building BAS Upgrade** job site,

on _____ at _____ AM PM (Circle One)

to inspect the proposed work, which would be turned over to me in its present condition, with a representative of the Contra Costa Community College District in order to acquaint myself with the proposed work so that I might fully understand the facilities, difficulties, and restrictions attending the execution of the work under the contract, and acknowledge I had the opportunity to check the Record Drawing as-built drawings and/or previous Contract Documents, site conditions and Bid Documents with the authorized representative of the District.

Owner Representative:

_____ _____
Project Manager / CM – CCCCD Facilities Date

or

_____ _____
Manager – Buildings & Grounds Date

Bidder:

_____
Name of Firm or Company

_____
Authorized Signatory

_____
Address

_____
Phone Number Fax Number

NOTE: Any bidder who fails to return this CERTIFICATION, fully executed, including signature of company representative AND a Contra Costa Community College District representative, with the proposal form, may have their bid rejected as non-responsive.

END OF SECTION 00450

PAYMENT BOND
(CALIFORNIA PUBLIC WORK)

KNOW ALL MEN BY THESE PRESENTS:

THAT WHEREAS, the Contra Costa Community College District (sometimes referred to hereinafter as "Obligee") has awarded to _____ (hereinafter designated as the "Principal" or "Contractor"), an agreement for the work described as follows: _____ (hereinafter referred to as the "Public Work"); and

WHEREAS, said Contractor is required to furnish a bond in connection with said Contract, and pursuant to California Civil Code Section 9550;

NOW, THEREFORE, We, _____, the undersigned Contractor, as Principal; and _____, a corporation organized and existing under the laws of the State of _____, and duly authorized to transact business under the laws of the State of California, as Surety, are held and firmly bound unto the Contra Costa Community College District and to any and all persons, companies, or corporations entitled by law to file stop notices under California Civil Code Section 9100, or any person, company, or corporation entitled to make a claim on this bond, in the sum of _____ Dollars ($_____), said sum being not less than one hundred percent (100%) of the total amount payable by said Obligee under the terms of said Contract, for which payment will and truly to be made, we bind ourselves, our heirs, executors and administrators, successors and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH that if said Principal, its heirs, executors, administrators, successors, or assigns, or subcontractor, shall fail to pay any person or persons named in Civil Code Section 9100; or fail to pay for any materials, provisions, or other supplies, used in, upon, for, or about the performance of the work contracted to be done, or for any work or labor thereon of any kind, or for amounts due under the Unemployment Insurance Code, with respect to work or labor thereon of any kind; or shall fail to deduct, withhold, and pay over to the Employment Development Department, any amounts required to be deducted, withheld, and paid over by Unemployment Insurance Code Section 13020 with respect to work and labor thereon of any kind, then said Surety will pay for the same, in an amount not exceeding the amount herein above set forth, and in the event suit is brought upon this bond, also will pay such reasonable attorneys' fees as shall be fixed by the court, awarded and taxed as provided in California Civil Code Sections 9550 et seq.

This bond shall inure to the benefit of any person named in Civil Code Section 9100 giving such person or his/her assigns a right of action in any suit brought upon this bond.

It is further stipulated and agreed that the Surety of this bond shall not be exonerated or released from the obligation of the bond by any change, extension of time for performance, addition, alteration or modification in, to, or of any contract, plans, or specifications, or agreement pertaining or relating to any scheme or work of improvement herein above described; or pertaining or relating to the furnishing of labor, materials, or equipment therefor; nor by any change or modification of any terms of payment or extension of time for payment pertaining or

relating to any scheme or work of improvement herein above described; nor by any rescission or attempted rescission of the contract, agreement or bond; nor by any conditions precedent or subsequent in the bond attempting to limit the right of recovery of claimants otherwise entitled to recover under any such contract or agreement or under the bond; nor by any fraud practiced by any person other than the claimant seeking to recover on the bond; and that this bond be construed most strongly against the Surety and in favor of all persons for whose benefit such bond is given; and under no circumstances shall the Surety be released from liability to those for whose benefit such bond has been given, by reason of any breach of contract between the Obligee and the Contractor or on the part of any obligee named in such bond; that the sole condition of recovery shall be that the claimant is a person described in California Civil Code Sections 9100, and who has not been paid the full amount of his or her claim; and that the Surety does hereby waive notice of any such change, extension of time, addition, alteration or modification herein mentioned.

IN WITNESS WHEREOF, we have hereunto set our hands and seals this_____ day of _____, 20____.

PRINCIPAL/CONTRACTOR:

_____

By: _____

SURETY:

_____

By: _____

Attorney-in-Fact

IMPORTANT: THIS IS A REQUIRED FORM.

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, Surety's name must also appear on the Treasury Department's most current list (Circular 570 as amended).

Any claims under this bond may be addressed to:

(Name and Address of Surety)	(Name and Address of agent or representative for service for service of process in California)
_____	_____
_____	_____
Telephone:_____	Telephone: _____

STATE OF CALIFORNIA)
) ss.
COUNTY OF)

On _____ before me, _____,
(insert name and title of the officer)
a Notary Public in and for said State, personally appeared _____, who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument as the Attorney-in-Fact of the _____ (Surety) and acknowledged to me that he/she/they subscribed the name of the _____ (Surety) thereto and his own name as Attorney-in-Fact on the executed instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

_____ (SEAL)
Notary Public in and for said State

Commission expires:_____

NOTE: A copy of the power-of-attorney to local representatives of the bonding company must be attached hereto.

CONTRACT PERFORMANCE BOND
(CALIFORNIA PUBLIC WORK)

KNOW ALL MEN BY THESE PRESENTS:

THAT WHEREAS, Contra Costa Community College District (sometimes referred to hereinafter as "Obligee") has awarded to _____ (hereinafter designated as the "Principal" or "Contractor"), an agreement for the work described as follows: _____ (hereinafter referred to as the "Public Work"); and

WHEREAS, the work to be performed by the Contractor is more particularly set forth in that certain contract for said Public Work dated _____ _____, (hereinafter referred to as the "Contract"), which Contract is incorporated herein by this reference; and

WHEREAS, the Contractor is required by said Contract to perform the terms thereof and to provide a bond both for the performance and guaranty thereof.

NOW, THEREFORE, we, _____, the undersigned Contractor, as Principal, and _____, a corporation organized and existing under the laws of the State of _____, and duly authorized to transact business under the laws of the State of California, as Surety, are held and firmly bound unto the Contra Costa Community College District in the sum of _____ Dollars ($_____), said sum being not less than one hundred percent (100%) of the total amount payable by said Obligee under the terms of said Contract, for which amount well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors, and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH THAT, if the bounded Contractor, his or her heirs, executors, administrators, successors or assigns, shall in all things stand to and abide by, and well and truly keep and perform the covenants, conditions, and agreements in said Contract and any alteration thereof made as therein provided, on his or her part, to be kept and performed at the time and in the manner therein specified, and in all respects according to their intent and meaning; and shall faithfully fulfill guarantees of all materials and workmanship; and indemnify, defend and save harmless the Obligee, its officers and agents, as stipulated in said Contract, then this obligation shall become null and void; otherwise it shall be and remain in full force and effect.

The Surety, for value received, hereby stipulates and agrees that it shall not be exonerated or released from the obligation of this bond (either by total exoneration or pro tanto) by any change, extension of time, alteration in or addition to the terms of the contract or to the work to be performed there under or the specifications accompanying the same, nor by any change or modification to any terms of payment or extension of time for any payment pertaining or relating to any scheme of work of improvement under the contract. Surety also stipulates and agrees that it shall not be exonerated or released from the obligation of this bond (either by total exoneration or pro tanto) by any overpayment or underpayment by the Obligee that is based upon estimates

approved by the Architect. The Surety stipulates and agrees that none of the aforementioned changes, modifications, alterations, additions, extension of time or actions shall in any way affect its obligation on this bond, and it does hereby waive notice of any such changes, modifications, alterations, additions or extension of time to the terms of the contract, or to the work, or the specifications as well notice of any other actions that result in the foregoing.

Whenever Principal shall be, and is declared by the Obligee to be, in default under the Contract, the Surety shall promptly either remedy the default, or shall promptly complete the Contract through its agents or independent contractors, subject to acceptance and approval of such agents or independent contractors by Obligee as hereinafter set forth, in accordance with its terms and conditions and to pay and perform all obligations of Principal under the Contract, including, without limitation, all obligations with respect to warranties, guarantees and the payment of liquidated damages; or, at Obligee's sole discretion and election, Surety shall obtain a bid or bids for completing the Contract in accordance with its terms and conditions, and upon determination by Obligee of the lowest responsible bidder, arrange for a contract between such bidder and the Obligee and make available as Work progresses (even though there should be a default or succession of defaults under the contract or contracts of completion arranged under this paragraph) sufficient funds to pay the cost of completion less the "balance of the Contract price" (as hereinafter defined), and to pay and perform all obligations of Principal under the Contract, including, without limitation, all obligations with respect to warranties, guarantees and the payment of liquidated damages. The term "balance of the Contract price," as used in this paragraph, shall mean the total amount payable to Principal by the Obligee under the Contract and any modifications thereto, less the amount previously paid by the Obligee to the Principal, less any withholdings by the Obligee allowed under the Contract.

Surety expressly agrees that the Obligee may reject any agent or contractor which may be proposed by Surety in fulfillment of its obligations in the event of default by the Principal. Unless otherwise agreed by Obligee, in its sole discretion, Surety shall not utilize Principal in completing the Contract nor shall Surety accept a bid from Principal for completion of the work in the event of default by the Principal.

No final settlement between the Obligee and the Contractor shall abridge the right of any beneficiary hereunder, whose claim may be unsatisfied.

The Contractor and Surety shall remain responsible and liable for all patent and latent defects that arise out of or are related to the Contractor's failure and/or inability to properly complete the Public Work as required by the Contract and the Contract Documents. The obligation of the Surety hereunder shall continue so long as any obligation of the Contractor remains.

Contractor and Surety agree that if the Obligee is required to engage the services of an attorney in connection with enforcement of the bond, Contractor and Surety shall pay Obligee's reasonable attorneys' fees incurred, with or without suit, in addition to the above sum.

In the event suit is brought upon this bond by the Obligee and judgment is recovered, the Surety shall pay all costs incurred by the Obligee in such suit, including reasonable attorneys' fees to be fixed by the Court.

IN WITNESS WHEREOF, we have hereunto set our hands and seals this _____ day of _____, 20____.

PRINCIPAL/CONTRACTOR:

_____

By: _____

SURETY:

_____

By: _____

Attorney-in-Fact

The rate of premium on this bond is _____ per thousand.

The total amount of premium charged: $_____ (This must be filled in by a corporate surety).

IMPORTANT: THIS IS A REQUIRED FORM.

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, Surety's name must also appear on the Treasury Department's most current list (Circular 570 as amended).

Any claims under this bond may be addressed to:

(Name and Address of Surety)	(Name and Address of agent or representative for service for service of process in California)
_____	_____
_____	_____
Telephone:_____	Telephone: _____

STATE OF CALIFORNIA)
) ss.
COUNTY OF)

On _____ before me, _____
(insert name and title of the officer)

On _____, before me, _____, a Notary

Public in and for said State, personally appeared _____, who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument as the Attorney-in-Fact of the _____ (Surety) and acknowledged to me that he/she/they subscribed the name of the _____ (Surety) thereto and his own name as Attorney-in-Fact on the executed instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

_____ (SEAL)
Notary Public in and for said State

Commission expires:_____

NOTE: A copy of the power-of-attorney to local representatives of the bonding company must be attached hereto.

SECTION 00510

NOTICE OF AWARD

DATE: _____

TO: _____

ADDRESS: _____

PROJECT: _____

The Contract Sum of your contract is _____ Dollars, ($_____).

You must comply with the following conditions within **ten (10)** calendar days of the date of this Notice of Award, that is, by _____.

1. You must deliver to the District two fully executed counterparts of Section 00600, "Construction Agreement."

2. You must deliver to the District the "Contract Performance Bond," and "Payment Bond," executed by you and your surety, which are included in Section 00500.

3. You must deliver to District the insurance certificates required in Section 00800, for insurance required in Section 00600, Construction Agreement.

Failure to comply with these conditions within the time specified will entitle District to consider your bid abandoned, to annul this Notice of Award, and to declare your Bid Security forfeited. Within **ten (10)** calendar days after you comply with these conditions, the District will return to you one fully signed counterpart of the Construction Agreement.

Contra Costa Community College District

By: _____

Title: _____

END OF DOCUMENT

SECTION 00600

CONSTRUCTION AGREEMENT

CONTRACT NO. _____
(Construction Agreement)

==========

This Agreement shall not be enforceable until ratified and approved by the Contra Costa Community College District's Governing Board. The estimated board meeting date is **May 11, 2022.**

(§1.1) Parties: (Public Agency) **CONTRA COSTA COMMUNITY COLLEGE DISTRICT**
500 Court St, Martinez, CA 94553

Contractor _____
Address: _____
_____

(§1.2) Effective Date: See Article 1.4, below.

(§1.3) The Work: **L-1201 Science Building BAS Upgrade**

(§1.4) Completion Time: **124 Calendar Days** from the Notice to Proceed to Substantial Completion, and **60 Calendar Days** from Substantial Completion to Final Completion (Remaining Work).

(§1.5.1) Liquidated Damages, Substantial Completion: **$1000** per Calendar Day beyond the Contract Substantial Completion Date.

(§1.5.2) Liquidated Damages, Remaining Work/Final Completion: **$500** per calendar day Remaining Work is delayed beyond the Contract Final Completion Date.

(§1.6) Public Agency's Agent: **CONTRA COSTA COMMUNITY COLLEGE DISTRICT ("District")**

(§1.7) Contract Sum: **xxx THOUSAND DOLLARS and NO CENTS ($000,000.00)**

2. SCOPE OF WORK:

In general, the Work consists of the following, but not limited to: Replacing the existing Andover direct digital control (DDC) systems and Triatek air valves at Los Medanos Science Building with a new ALC Building Automation System (BAS) and AccuValve air valves. See Section 00010, Table of Contents, for a list of all the Contract Documents (specifications and drawings) included in this the scope of work, including addendums issued and referenced in the Contractor's bid form (Section 00300).

3. WORK CONTRACT, CHANGES

(a) By their signatures below, effective on the above date, these parties promise and agree as set forth in this Agreement, incorporating by these references labor and materials contained in Section 2, Scope of Work.

(b) Contractor shall, at Contractor's own cost and expense, and in a workmanlike manner, fully and faithfully perform and complete the work; and will furnish all materials, labor, services, equipment, and transportation necessary, convenient and proper in order fairly to perform the requirements of this contract, all strictly in accordance with the Public Agency's- drawings and specifications.

(c) The work can be changed only with Public Agency's prior written order specifying such change and its cost agreed to by the parties; and the Public Agency shall never have to pay more than specified in Section 1.7 without such an order.

4. TIME: NOTICE TO PROCEED AND ACCEPTANCE

(a) Contractor shall start this work as directed in the specifications or the Notice to Proceed and shall complete it as specified in Section 1, Completion Time.

(b) Remaining Work after Substantial Completion. If the Architect or District determines that the work required by the Contract is Substantially Complete during any inspection conducted pursuant to this Agreement or **Specification Section 00800, SUPPLEMENTARY GENERAL CONDITIONS**, the Contractor shall be notified of that determination and the District shall determine if there is Remaining Work. A list of Remaining Work shall be issued only by the District or the Architect and only after the District has certified Substantial Completion. The District or Architect shall give the Contractor the necessary instructions for correction or completion of the Remaining Work, and the Contractor shall immediately comply with and execute such instructions within the Contract Time. Upon completion of the Remaining Work, another inspection shall be made that shall constitute the Final Inspection, provided the Remaining Work has been completed to the satisfaction of the District. If the remaining work has been completed to the satisfaction of the District, the District shall make the final acceptance and notify the Contractor in writing of this acceptance as of the date of Final Inspection.

(c) Final Acceptance – Upon due notice from the Contractor of completion of the entire project, the District shall make an inspection. If all construction provided for and contemplated by the contract is found to be completed to the District's satisfaction, then that inspection shall constitute the Final Inspection and the District shall notify the Contractor in writing of final acceptance effective as of the date of the Final Inspection.

(d) Default for failure to Complete Remaining Work In the event the Contract Time expires before the Remaining Work is completed to the satisfaction of the District, the District may provide notice to the Contractor that the Remaining Work shall be completed by Contractor to the satisfaction of the District within ten consecutive calendar days from the date of such notice. The failure of the Contractor to satisfactorily complete the Remaining Work within the ten days shall entitle to District to declare Contractor in default and thereafter terminate the Contract. The ten-day notice provided under this paragraph shall not be construed as adding any time to the Contract Time and is a time period solely for the purposes of providing notice of default.

(e) Application for Final Payment. After the Contractor has completed all Remaining Work to the satisfaction of the District and delivered all maintenance and operating instructions, schedules, guarantees, warranties, bonds, certificates of inspection, marked-up record documents and other documents as required by the Contract, and after the District or Architect has indicated that the

work is acceptable, Contractor may make application for final payment following the Payments Procedures for progress payments. The final application for payment shall be accompanied by all documentation called for in the Contract Documents, together with complete and legally effective releases or waivers (satisfactory to the District) of all liens arising out of or filed in connection with the work on the project.

(f) Final Payment and Acceptance. If the Architect determines that the work has been completed and the Contractor's other obligations under the Contract have been fulfilled, the Architect shall, within ten working days after receipt of the final application for payment, indicate in writing the Architect's recommendation of payment and present the application to District for payment. Thereupon the Architect shall prepare a Certificate of Final Completion. Otherwise, Architect shall return the application to Contractor indicating in writing the reasons for refusing to recommend final payment. Contractor shall make the corrections identified in the Architect's refusal to recommend final payment. Thirty days after presentation to District of the application and accompanying documentation, with the Architect's recommendation and notice of acceptability of the work, the amount recommended by Architect shall be come due and payable by District to Contractor.

5. LIQUIDATED DAMAGES

5.1 LIQUIDATED DAMAGES - SUBSTANTIAL COMPLETION

If the Contractor fails to complete this contract and this Work within the time fixed therefore, allowance being made for contingencies as provided herein, Contractor becomes liable to the Public Agency for all its loss and damage there from; and because, from the nature of the case, it is and will be impracticable and extremely difficult to ascertain and fix the Public Agency's actual damage from any delay in performance hereof, it is agreed that Contractor will pay as liquidated damages to the Public Agency the reasonable sum specified in Section 1, the result of the parties' reasonable endeavor to estimate fair average compensation therefore, for each calendar day's delay in finishing said Work; and if the same be not paid, Public Agency may, in addition to its other remedies, deduct the same from any money due or to become due Contractor under this Contract. If the Public Agency for any cause authorizes or contributes to a delay, suspension of work or extension of time, its duration shall be added to the time allowed for completion, but it shall not be deemed a waiver nor be used to defeat any right of the Agency to damages for non-completion or delay hereunder. Pursuant to Government Code Section 4215, the Contractor shall not be assessed liquidated damages for delay in completion of the work, when such delay was caused by the failure of the Public Agency or the owner of a utility to provide for removal or relocation of existing utility facilities.

5.2 LIQUIDATED DAMAGES-THE REMAINING WORK

The Remaining Work, as such work is determined by the Public Agency or Public Agency's Representative, shall be completed within the Contract Time or any proper extension thereof granted by Public Agency. If the Contractor shall neglect, fail or refuse to complete the Remaining Work within the Contract Time or any proper extension thereof granted by the Public Agency, then the Contractor does hereby agree, as part consideration for the awarding of this Contract, to pay to the Public Agency the amount specified in the Contract, not as a penalty but as liquidated damages for the Remaining Work for each such breach of Contract set forth herein for each and every consecutive calendar day that the Contractor shall be in default after expiration of the Contract Time.

6. INTEGRATED DOCUMENTS

The drawings and specifications and special provisions of the Public Agency's Notice Inviting Bids, and Contractor's accepted bid for this work are hereby incorporated into this Contract; and they are intended to cooperate, so that anything exhibited in the drawings and not mentioned in the specifications or special provisions, or vice versa, is to be executed as if exhibited, mentioned and set forth in both, to the true intent and meaning thereof when taken all together; and differences of opinion concerning these shall be finally determined by the Public Agency.

7. PAYMENT

(a) For strict and literal fulfillment of these promises and conditions, and full compensation for all this work, the Public Agency shall pay the Contractor the sum specified in Section 1, except that in unit price contracts the payment shall be for finished quantities at unit bid prices.

(b) On or about the first day of each calendar month, the Contractor shall submit to the Public Agency a verified application for payment, supported by a statement showing all materials actually installed during the preceding month, the labor expended thereon, and the cost thereof; whereupon, after checking, the Public Agency shall issue to Contractor a certificate for the amount determined to be due, minus five (5%) percent thereof pursuant to the Public Agency's General Terms and Conditions, but not until defective work and materials have been removed, replaced and made good.

8. PAYMENTS WITHHELD

(a) The Public Agency or its agent may withhold any payment, or because of later discovered evidence nullify all or any certificate for payment, to such extent and period of time only as may be necessary to protect the Public Agency from loss because of:

(1) Defective work not remedied, or work not completed, or
(2) Claims filed or reasonable evidence indicating probable filing, or
(3) Failure to properly pay subcontractors or for material or labor, or
(4) Reasonable doubt that the work can be completed for the balance then unpaid, or
(5) Damage to another contractor, or
(6) Damage to the Public Agency, other than damage due to delays.

(b) The Public Agency shall use reasonable diligence to discover and report to the Contractor, as the work progresses, the materials and labor which are not satisfactory to it, so as to avoid unnecessary trouble or cost to the Contractor in making good any defective work or parts.

(c) Thirty-five (35) calendar days after Public Agency files its notice of completion of the entire work, it shall issue a certificate to the Contractor and pay the balance of the contract sum after deducting all amounts withheld under this contract, provided the Contractor shows that all claims for labor and materials have been paid, no claims have been presented to the Public Agency based on acts or omissions of the Contractor, and no liens or withhold notices have been filed against the work or site, and provided there are not reasonable indications of defective or missing work or of late-recorded notices of liens or claims against Contractor.

9. INSURANCE

Contractor's Liability Insurance: Before the commencement of the Work, the Contractor shall purchase from and maintain in a company or companies lawfully authorized to do business in California as admitted carriers with a financial rating of at least A status as rated in the most recent edition of Best's Insurance Reports or as amended by the Supplementary General Conditions, if any, such insurance as will protect the Public Agency from claims set forth below, which may arise out of or result from the Contractor's operations under the Contract and for which the Contractor may be legally liable, whether such operations are by the Contractor, by a Subcontractor, by anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable.

(a) Claims for damages because of bodily injury, sickness, disease, or death of any person District would require indemnification and coverage for employee claim;

(b) Claims for damages insured by usual personal injury liability coverage, which are sustained by a person as a result of an offense directly or indirectly related to employment of such person by the Contractor or by another person;

(c) Claims for damages because of injury or destruction of tangible property, including loss of use resulting therefrom, arising from operations under the Contract Documents;

(d) Claims for damages because of bodily injury, death of a person, or property damage arising out of the ownership, maintenance, or use of a motor vehicle, all mobile equipment, and vehicles moving under their own power and engaged in the Work;

(e) Claims involving contractual liability applicable to the Contractor's obligations under the Contract Documents, including liability assumed by and the indemnity and defense obligations of the Contractor and the Subcontractors; and

(f) Claims involving Completed Operations, Independent Contractors' coverage, and Broad Form property damage, without any exclusions for collapse, explosion, demolition, underground coverage, and excavating. (XCU)

(g) Claims involving sudden or accidental discharge of contaminants or pollutants.

Subcontractor Insurance Requirements: The Contractor shall require its Subcontractors to take out and maintain similar public liability insurance and property damage insurance as required under the above paragraph, titled "Contractor's Liability Insurance, in amounts commensurate with the value of the subcontract. A "claims made" or modified "occurrence" policy shall not satisfy the requirements of the above paragraph, titled "Contractor's Liability Insurance, without prior written approval of the District.

Additional Insured Endorsement Requirement: The Contractor shall name, on any policy of insurance, the District, Architect, Inspector, the State of California, their officers, employees, agents and independent contractors as Additional Insured. Subcontractors shall name the Contractor, the District, Architect, Inspector, the State of California, their officers, employees, agents and independent contractors as Additional Insured.

The Additional Insured Endorsement included on all such insurance policies shall state that coverage is afforded the additional insured with respect to claims arising out of operations performed by or on behalf of the insured. If the Additional Insured have other insurance which is applicable to the loss, such other insurance shall be on an excess or contingent basis. The insurance provided by the Contractor

must be designated in the policy as primary to any insurance obtained by the Public Agency. The amount of the insurer's liability shall not be reduced by the existence of such other insurance.

Workers' Compensation Insurance: During the term of this Contract, the Contractor shall provide workers' compensation insurance for all of the Contractor's employees engaged in Work under this Contract on or at the Site of the Project and, in case any of the Contractor's Work is subcontracted, the Contractor shall require the Subcontractor to provide workers' compensation insurance for all the Subcontractor's employees engaged in Work under the subcontract. Any class of employee or employees not covered by a Subcontractor's insurance shall be covered by the Contractor's insurance. In case any class of employees engaged in Work under this Contract on or at the Site of the Project is not protected under the Workers' Compensation laws, the Contractor shall provide or cause a Subcontractor to provide adequate insurance coverage for the protection of those employees not otherwise protected. The Contractor shall file with the District certificates of insurance as required under Section 00700, Article 11.6, and in compliance with Labor Code § 3700.

Specific Insurance Requirement: Contractor shall take out and maintain and shall require all subcontractors, if any, whether primary or secondary, to take out and maintain:

(a) Workers' Compensation Insurance: $1,000,000.00; Contractor is aware of and complies with Labor Code Section 3700 and the Worker's Compensation Law.

(b) Comprehensive General Liability Insurance with a combined single limit per occurrence of not less than $1,000,000.00 and $2,000,000.00 project specific aggregate, or Commercial General Liability Insurance (including automobile insurance) which provides limits of not less than:

(1)	Per occurrence (combined single limit)	$1,000,000.00
(2)	Project Specific Aggregate (for this project only)	$2,000,000.00
(3)	Products and Completed Operations	$1,000,000.00

(c) Insurance Covering Special Hazards

The following Special hazards shall be covered by riders or riders to above mentioned public liability insurance or property damage insurance policy or policies of insurance, in amounts as follows:

(1)	Automotive and truck where operated in amounts	$1,000,000.00
(2)	Material Hoist where used in amounts	$1,000,000.00
(3)	Explosion, Collapse and Underground (XCU coverage)	$1,000,000.00

(d) In addition, provide Excess Liability Insurance coverage in the amount of Two Million Dollars ($2,000,000.00).

Builder's Risk/ "All Risk" Insurance/Course-of-Construction Insurance Requirements: The Contractor, during the progress of the Work and until final acceptance of the Work by District upon completion of the entire Contract, shall maintain Builder's Risk, Course of Construction or similar first party property coverage issued on a replacement cost value basis consistent with the total replacement cost of all insurable Work and the Project included within the Contract Documents. Coverage is to insure against all risks of accidental direct physical loss, and must include, by the basic grant of coverage or by endorsement, the perils of vandalism, malicious mischief (both without any limitation regarding vacancy or occupancy), fire, sprinkler leakage, civil authority, sonic boom, earthquake, flood, collapse, wind,

lightning, smoke and riot. The coverage must include debris removal, demolition, increased costs due to enforcement of building ordinance and law in the repair and replacement of damage and undamaged portions of the property, and reasonable costs for the Architect's and engineering services and expenses required as a result of any insured loss upon the Work and Project which is the subject of the Contract Documents, including completed Work and Work in progress, to the full insurable value thereof. Such insurance shall include the District and the Architect as additional named insureds, and any other person with an insurable interest as designated by the District.

The Contractor shall submit to the District for its approval all items deemed to be uninsurable. The risk of the damage to the Work due to the perils covered by the "Builder's Risk/All Risk" Insurance, as well as any other hazard which might result in damage to the Work, is that of the Contractor and the surety, and no claims for such loss or damage shall be recognized by the District nor will such loss or damage excuse the complete and satisfactory performance of the Contract by the Contractor.

10. BONDS

Bond Requirements: Prior to commencing any portion of the Work, the Contractor shall furnish separate payment and performance bonds for its portion of the Work which shall cover 100% faithful performance of and payment of all obligations arising under the Contract Documents and/or guaranteeing the payment in full of all claims for labor performed and materials supplied for the Work. All bonds shall be provided by a corporate surety authorized and admitted to transact business in California as sureties.

To the extent, if any, that the Contract Sum is increased in accordance with the Contract Documents, the Contractor shall, upon request of the Public Agency, cause the amount of the bonds to be increased accordingly and shall promptly deliver satisfactory evidence of such increase to the Public Agency. To the extent available, the bonds shall further provide that no change or alteration of the Contract Documents (including, without limitation, an increase in the Contract Sum, as referred to above), extensions of time, or modifications of the time, terms, or conditions of payment to the Contractor will release the surety. If the Contractor fails to furnish the required bonds, the Public Agency may terminate the Contract for cause.

On signing this contract, Contractor shall deliver to Public Agency for approval good and sufficient bonds with sureties, in amount(s), specified in the specifications or special provisions, guaranteeing faithful performance of this contract and payment for all labor and materials hereunder.

Surety Qualifications: Only bonds executed by admitted Surety insurers as defined in Code of Civil Procedure § 995.120 shall be accepted. Surety must be a California-admitted surety and listed by the U.S. Treasury with a bonding capacity in excess of the Project cost.

Alternate Surety Qualifications: If a California-admitted surety insurer issuing bonds does not meet these requirements, the insurer will be considered qualified if it is in conformance with § 995.660 of the California Code of Civil Procedure and proof of such is provided to the District.

11. FAILURE TO PERFORM

If the Contractor at any time refuses or neglects, without fault of the Public Agency or its agent(s), to supply sufficient materials or workers to complete this agreement and work as provided herein, for a

period of ten days or more after written notice thereof by the Public Agency, the Public Agency may furnish same and deduct the reasonable expenses thereof from the contract price.

12. LAWS APPLY: General

Both parties recognize the applicability of various federal, state and local laws and regulations, especially Chapter 1 of Part 7 of the California Labor Code (beginning with Section 1720, and including Sections 1735, 1777.5, 1777.6, forbidding discrimination) and intend that this agreement complies therewith. The parties specifically stipulate that the relevant penalties and forfeitures provided in the Labor Code, especially in Sections 1775, 1776, and 1813, concerning prevailing wages and hours, shall apply to this agreement as though fully stipulated herein.

13. SUBCONTRACTORS

Public Contract Code Sections 4100-4113 are incorporated herein.

14. WAGE RATES

(a) Pursuant to Labor Code Section 1773, the Director of the Department of Industrial Relations has ascertained the general prevailing rates of wages per diem, and for holiday and overtime work, in the locality in which this work is to be performed, for each craft, specified in the call for bids for this work and are on file with the Public Agency, and are hereby incorporated herein.

(b) This schedule of wages is based on a working day of eight (8) hours unless otherwise specified; and the daily rate is the hourly rate multiplied by the number of hours constituting the working day. When less than that number of hours are worked, the daily wage rage is proportionately reduced, but the hourly rate remains as stated.

(c) The Contractor, and all subcontractors, must pay at least these rates to all persons on this work, including all travel, subsistence, and fringe benefit payments provided for by applicable collective bargaining agreements. All skilled labor not listed above must be paid at least the wage scale established by collective bargaining agreement for such labor in the locality where such work is being performed. If it becomes necessary for the Contractor or any subcontractor to employ any person in a craft, classification or type of work (except executive, supervisory, administrative, clerical or other non-manual workers as such) for which no minimum wage rate is specified, the contractor shall immediately notify the Public Agency which shall promptly determine the prevailing wage rate therefore and furnish the Contractor with the minimum rate based thereon, which shall apply from the time of the initial employment of the person affected and during the continuance of such employment.

15. HOURS OF LABOR

Eight hours of labor in one calendar day constitutes a legal day's work, and no worker employed at any time on this work by the Contractor or by any subcontractor shall be required or permitted to work longer thereon except as provided in Labor Code Sections 1810-1815.

16. APPRENTICES

Properly indentured apprentices may be employed on this work in accordance with Labor Code Sections 1777.5 and 1777.6, forbidding discrimination.

17. PREFERENCE FOR MATERIALS

The Public Agency desires to promote the industries and economy of Contra Costa County, and the Contractor therefore promises to use the products, workers, laborers and mechanics of this County in every case where the price, fitness and quality are at least equal.

18. ASSIGNMENT

This agreement binds the heirs, successors, assigns, and representatives of the Contractor; but Contractor cannot assign it in whole or in part, nor any monies due or to become due under it, without the prior written consent of the Public Agency and the Contractor's surety or sureties, unless they have waived notice of assignment.

19. NO WAIVER BY PUBLIC AGENCY

Inspection of the work and/or materials, or approval of work and/or materials inspected, or statement by any officer, agent or employee of the Public Agency indicating the work or any part thereof complies with the requirements of this contract, or acceptance of the whole or any part of said work and/or materials, or payments therefore, or any combination of these acts, shall not relieve the Contractor of Contractor's obligation to fulfill this contract as prescribed; nor shall the Public Agency be thereby stopped from bringing any action for damages or enforcement arising from the failure to comply with any of the terms and conditions hereof.

20. HOLD HARMLESS AND INDEMNITY

(a) Contractor promises to and shall hold harmless and indemnify from the liabilities as defined in this section.

(b) The indemnities benefited and protected by this promise are the Public Agency and its elective and appointive boards, commissions, officers, agents and employees.

(c) The liabilities protected against are any liability or claim for damage of any kind allegedly suffered, incurred or threatened because of actions defined below, including personal injury, death, property damage, inverse condemnation, or any combination of these, regardless of whether or not such liability, claim or damage was unforeseeable at any time before the Public Agency approved the improvement plan or accepted the improvements as completed, and including the defense of any suit(s) or action(s) at law or equity concerning these.

(d) The actions causing liability are any act or omission (negligent or non-negligent) in connection with the matters covered by this contract and attributable to the contractor, subcontractor(s), or any officer(s), agent(s), or employee(s) of one or more of them.

(e) Non-conditions: The promise and agreement in this section is not conditioned or dependent on whether or not any Indemnities has prepared, supplied, or approved any plan(s), drawing(s),

specifications(s) or special provision(s) in connection with this work, has insurance or other indemnification covering any of these matters, or that the alleged damage resulted partly from any negligent or willful misconduct of any Indemnities.

21. EXCAVATION

Contractor shall comply with the provisions of Labor Code Section 6705, if applicable, by submitting to Public Agency a detailed plan showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground during trench excavation.

22. GOVERNMENT CODE SECTION 10532

Contractor shall be subject to the examination and audit of the Auditor General for a period of three years after final payment under the contract.

23. WARRANTY

(a) In addition to any other warranties or guaranties in the Contract Documents, the Contractor warrants, except as provided in paragraph (i) of this clause, that work performed under this contract conforms to the contract requirements and is free of any defect in equipment, material, or design furnished, or workmanship performed by the Contractor or any subcontractor or supplier at any tier.

(b) This warranty shall continue for a period of 1 year from the date of final acceptance of the Work or Phase of Work, unless otherwise provided or extended in the Contract Documents. If the District takes possession of any part of the work before final acceptance, this warranty shall continue for a period of 1 year from the date the District takes possession.

(c) The Contractor shall remedy at the Contractor's expense any failure to conform, or any defect. In addition, the Contractor shall remedy at the Contractor's expense any damage to District-owned or controlled real or personal property, when that damage is the result of—

(1) The Contractor's failure to conform to contract requirements; or
(2) Any defect of equipment, material, workmanship, or design furnished.

(d) The Contractor shall restore any work damaged in fulfilling the terms and conditions of this clause. The Contractor's warranty with respect to work repaired or replaced will run for 1 year or as otherwise provided or extended from the date of repair or replacement.

(e) The District shall notify the Contractor, in writing, within a reasonable time after the discovery of any failure, defect, or damage.

(f) If the Contractor fails to remedy any failure, defect, or damage within a reasonable time after receipt of notice, the District shall have the right to replace, repair, or otherwise remedy the failure, defect, or damage at the Contractor's expense.

(g) With respect to all warranties, express or implied, from subcontractors, manufacturers, or suppliers for work performed and materials furnished under this contract, the Contractor shall—

(1) Obtain all warranties that would be given in normal commercial practice;

(2) Require all warranties to be executed, in writing, for the benefit of the District, if directed by the District; and
(3) Enforce all warranties for the benefit of the District, if directed by the District.

(h) In the event the Contractor's warranty under paragraph (b) of this clause has expired, the District may bring suit at its expense to enforce a subcontractor's, manufacturer's, or supplier's warranty.

(i) Unless a defect is caused by the negligence of the Contractor or subcontractor or supplier at any tier, the Contractor shall not be liable for the repair of any defects of material or design furnished by the District nor for the repair of any damage that results from any defect in District-furnished material or design.

(j) This warranty shall not limit the District's rights under the Inspection and Acceptance clause of this contract with respect to latent defects, gross mistakes, or fraud.

24. CONSEQUENTIAL DAMAGES

The Contractor and Public Agency waive Claims against each other for consequential damages arising out of or relating to this Contract. This mutual waiver includes:

(a) Damages incurred by the Public Agency for rental expenses, for losses of use, income, profit, financing, business and reputation, and for loss of management or employee productivity or of the services of such persons; and

(b) Damages incurred by the Contractor for principal office expenses including the compensation of personnel stationed there, for losses of financing, business and reputation, and for loss of profit except anticipated profit arising directly from the Work.

This mutual waiver is applicable, without limitation, to all consequential damages due to either party's termination. Nothing contained in this subparagraph shall be deemed to preclude an award of liquidated direct damages, when applicable, in accordance with the requirements of the Contract Documents.

25. HAZARDOUS MATERIALS

(a) If reasonable precautions will be inadequate to prevent foreseeable bodily injury or death to persons resulting from a material or substance, including but not limited to asbestos, lead or polychlorinated biphenyl (PCB), encountered on the site by the Contractor, the Contractor shall, upon recognizing the condition, immediately stop Work in the affected area and report the condition to the Public Agency in writing.

(b) The Public Agency shall obtain the services of a licensed laboratory to verify the presence or absence of the material or substance reported by the Contractor and, in the event such material or substance is found to be present, to verify that it has been rendered harmless. The Public Agency shall furnish in writing to the Contractor the names and qualifications of persons or entities who are to perform tests verifying the presence or absence of such material or substance or who are to perform the task of removal or safe containment of such material or substance. When the material or substance has been rendered harmless, Work in the affected area shall resume upon written notification from the Public Agency and Contractor. The Contract Time shall be extended appropriately.

26. SAFETY

(a) **Safety Programs.** In addition to and as required by other Sections of the Contract Documents, the Contractor shall be solely responsible for initiating, maintaining and supervising all safety programs required by applicable law, ordinance, regulation or governmental orders in connection with the performance of the Contract, or otherwise required by the type or nature of the Work. The Contractor's safety program shall include all actions and programs necessary for compliance with California or federally statutorily mandated workplace safety programs, including without limitation, compliance with the California Drug Free Workplace Act of 1990 (California Government Code §§8350 et seq.). Without limiting or relieving the Contractor of its obligations hereunder, the Contractor shall require that its Subcontractors similarly initiate and maintain all appropriate or required safety programs. Prior to commencement of Work, the Contractor shall meet with the Campus Buildings and Grounds Manager, Project Manager, and Construction Manager to review Contractor's safety precautions and implementation of safety programs during the Work.

(b) **Safety Precautions.** In addition to and as required by other Sections of the Contract Documents, the Contractor shall be solely responsible for initiating and maintaining reasonable precautions for safety of, and shall provide reasonable protection to prevent damage, injury or loss to: (i) employees on the Work and other persons who may be affected thereby; (ii) the Work and materials and equipment to be incorporated therein, whether in storage on or off the site, under care, custody or control of the Contractor or the Contractor's Subcontractors or Sub-subcontractors; and (iii) other property or items at the site of the Work, or adjacent thereto, such as trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction. The Contractor shall take adequate precautions and measures to protect existing roads, sidewalks, curbs, pavement, utilities, adjoining property and improvements thereon (including without limitation, protection from settlement or loss of lateral support) and to avoid damage thereto. Without adjustment of the Contract Price or the Contract Time, the Contractor shall repair, replace or restore any damage or destruction of the foregoing items as a result of performance or installation of the Work.

(c) **Safety Signs, Barricades. In addition to and as required by other Sections of the Contract** Documents, the Contractor shall erect and maintain, as required by existing conditions and conditions resulting from performance of the Contract, reasonable safeguards for safety and protection of property and persons, including, without limitation, posting danger signs and other warnings against hazards, promulgating safety regulations and notifying Districts and users of adjacent sites and utilities.

(d) **Safety Notices.** In addition to and as required by other Sections of the Contract Documents, the Contractor shall give or post all notices required by applicable law and comply with applicable laws, ordinances, rules, regulations and lawful orders of public authorities bearing on safety of persons or property or their protection from damage, injury or loss.

~~**27. PROJECT STABILIZATION AGREEMENT**~~

~~(a) Definitions. As used in this clause — "Project Stabilization Agreement" (hereinafter "PSA") means the pre-hire collective bargaining agreement between the Contra Costa Community College District and the Contra Costa~~

Building and Construction Trades Council attached to these Contract Documents which establishes the terms and conditions of employment for the Project.

(b) Contracts.

(1) The Contractor/Employer shall maintain in a current status, throughout the life of this Contract, the PSA included in these Contract Documents. By accepting the award of this Construction Contract for the Project, whether as Contractor or subcontractor, the Contractor/Employer agrees to be bound by each and every provision of the PSA, and evidence its acceptance prior to the commencement of work by executing the PSA Agreement to be Bound in the form attached to the PSA found in these Contract Documents.

(2) Subcontracts. At the time that any Contractor/Employer enters into a subcontract with any subcontractor providing for the performance of the construction subcontract, the Contractor/Employer shall provide a copy of the PSA to said subcontractor and shall require the subcontractor, as a part of accepting an award of a construction subcontract, to agree in writing to be bound by each and every provision of the PSA, and agree that it will evidence its acceptance prior to the commencement of work by executing the PSA Agreement to be Bound in the form attached to the PSA found in these Contract Documents.

(c) Reporting.

(1) PSA Preconstruction Conference. The Contractor/Employer shall, prior to the commencement of work under this Contract, hold a Preconstruction Conference in accordance with PSA Article 5 PRECONSTRUCTION CONFERENCE which shall be attended by a representative from each Contractor/Employer, the Unions, and the District. The Contractor/Employer shall contact the Contra Costa Building and Construction Trades Council at least two (2) weeks prior to scheduling the Preconstruction Conference so that the Unions can be notified of the date, time, and place of the Conference.

i. The Contractor/Employer shall lead the Preconstruction Conference and take minutes of the meeting.

ii. The Contractor/Employer shall submit written meeting minutes of the Conference in a form preapproved by the District within five (5) working days. The minutes shall include the names and organizations of each person attending the Conference. The minutes shall also include copies of the Agreements to be Bound required by this Contract and the PSA.

(d) Monthly Reporting. During each month in which construction work is performed by the Contractor/Employer or by any subcontractor, from Notice to Proceed through Notice of Completion, report the information required below to the District as a monthly administrative Submittal. These reports shall be submitted with each regularly scheduled payment application, or the application will be returned to the Contractor/Employer for resubmittal with the required reports.

(1) New Agreements to be Bound resulting from new subcontracts, if any, entered into by each Contractor/Employer.

(2) Each instance during the reporting period of which a Union is unable to fill a requisition for employees thereby causing the Contractor/Employer to apply Article 8 REFERRAL Clause 8.3, to obtain qualified work persons for the Contract work.

(3) A summary of efforts during the reporting period to comply with the goals of Article 10 LOCAL HIRE, including a spreadsheet report of the number of hours worked by all journeymen and by all apprentices on site, and the subset of the number of hours worked by journeymen and by apprentices who are residents of Contra Costa County.

~~(4) A summary of efforts to utilize the Center for Military Recruitment, Assessment and Veterans Employment, in accordance with Article 15 HELMETS TO HARDHATS.~~

27. SIGNATURES AND ACKNOWLEDGEMENT

Public Agency, By: _____
Amy Sterry, Director of Purchasing and Contracts

Note to Contractor: (1) Execute acknowledgement form below, and (2) if a corporation, affix Corporate Seal.

Contractor hereby also acknowledging awareness of and compliance with Labor Code S1861 concerning Worker's Compensation Law.

Contractor:

By: _____ (CORPORATE SEAL)
(Designate Official Capacity) **NAME**

_____
Print NAME and TITLE

_____ _____
License Number Federal ID Number

NOTARY PUBLIC

==========

State of California)ss. ACKNOWLEDGEMENT (By Corporation, Partnership or Individual)
County of Contra Costa)

The person(s) signing above for Contractor, known to me in individual and business capacity as stated, personally appeared before me today and acknowledged that he/she/they executed it and that the corporation or partnership named above executed it.

Dated: _____

(NOTARIAL SEAL)

END OF SECTION 00600

Appendix B-1

Small Construction Project Safety Protocol

1. Any construction project meeting any of the following specifications is subject to this Small Construction Project Safety Protocol ("SCP Protocol"), including public works projects unless otherwise specified by the Health Officer:

    a. For residential projects, any single-family, multi-family, senior, student, or other residential construction, renovation, or remodel project consisting of 10 units or less. This SCP Protocol does not apply to construction projects where a person is performing construction on their current residence either alone or solely with members of their own household.

    b. For commercial projects, any construction, renovation, or tenant improvement project consisting of 20,000 square feet of floor area or less.

    c. For mixed-use projects, any project that meets both of the specifications in subsection 1.a and 1.b.

    d. All other construction projects not subject to the Large Construction Project Safety Protocol set forth in Appendix B-2.

2. The following restrictions and requirements must be in place at all construction job sites subject to this SCP Protocol:

    a. Comply with all applicable and current laws and regulations including but not limited to OSHA and Cal-OSHA. If there is any conflict, difference, or discrepancy between or among applicable laws and regulations and/or this SCP Protocol, the stricter standard shall apply.

    b. Designate a site-specific COVID-19 supervisor or supervisors to enforce this guidance. A designated COVID-19 supervisor must be present on the construction site at all times during construction activities. A COVID-19 supervisor may be an on-site worker who is designated to serve in this role.

    c. The COVID-19 supervisor must review this SCP Protocol with all workers and visitors to the construction site.

    d. Establish a daily screening protocol for arriving staff to ensure that potentially infected staff do not enter the construction site. If workers leave the jobsite and return the same day, establish a cleaning and decontamination protocol prior to entry and exit of the jobsite. Post the daily screening protocol at all entrances and exits to the jobsite. More information on screening can be found online at: https://www.cdc.gov/coronavirus/2019-ncov/community/index.html.

    e. Practice social distancing by maintaining a minimum six-foot distance between workers at all times, except as strictly necessary to carry out a task associated with the construction project.

f. Where construction work occurs within an occupied residential unit, separate work areas must be sealed off from the remainder of the unit with physical barriers such as plastic sheeting or closed doors sealed with tape to the extent feasible. If possible, workers must access the work area from an alternative entry/exit door to the entry/exit door used by residents. Available windows and exhaust fans must be used to ventilate the work area. If residents have access to the work area between workdays, the work area must be cleaned and sanitized at the beginning and at the end of workdays. Every effort must be taken to minimize contact between workers and residents, including maintaining a minimum of six feet of social distancing at all times.

g. Where construction work occurs within common areas of an occupied residential or commercial building or a mixed-use building in use by on-site employees or residents, separate work areas must be sealed off from the rest of the common areas with physical barriers such as plastic sheeting or closed doors sealed with tape to the extent feasible. If possible, workers must access the work area from an alternative building entry/exit door to the building entry/exit door used by residents or other users of the building. Every effort must be taken to minimize contact between worker and building residents and users, including maintaining a minimum of six feet of social distancing at all times.

h. Prohibit gatherings of any size on the jobsite, including gatherings for breaks or eating, except for meetings regarding compliance with this protocol or as strictly necessary to carry out a task associated with the construction project.

i. Cal-OSHA requires employers to provide water, which should be provided in single-serve containers. Sharing of any of any food or beverage is strictly prohibited and if sharing is observed, the worker must be sent home for the day.

j. Provide personal protective equipment (PPE) specifically for use in construction, including gloves, goggles, face shields, and face coverings as appropriate for the activity being performed. At no time may a contractor secure or use medical-grade PPE unless required due to the medical nature of a jobsite. Face coverings must be worn in compliance with Section 5 of the Health Officer's Order No. HO-COVID19-08, dated April 17, 2020, or any subsequently issued or amended order.

k. Strictly control "choke points" and "high-risk areas" where workers are unable to maintain six-foot social distancing and prohibit or limit use to ensure that six-foot distance can easily be maintained between individuals.

l. Minimize interactions and maintain social distancing with all site visitors, including delivery workers, design professional and other project consultants, government agency representatives, including building and fire inspectors, and residents at residential construction sites.

m. Stagger trades as necessary to reduce density and allow for easy maintenance of minimum six-foot separation.

n. Discourage workers from using others' desks, work tools, and equipment. If more than one worker uses these items, the items must be cleaned and disinfected with disinfectants that are effective against COVID-19 in between use by each new worker. Prohibit sharing of PPE.

o. If hand washing facilities are not available at the jobsite, place portable wash stations or hand sanitizers that are effective against COVID-19 at entrances to the jobsite and in multiple locations dispersed throughout the jobsite as warranted.

p. Clean and sanitize any hand washing facilities, portable wash stations, jobsite restroom areas, or other enclosed spaces daily with disinfectants that are effective against COVID-19. Frequently clean and disinfect all high touch areas, including entry and exit areas, high traffic areas, rest rooms, hand washing areas, high touch surfaces, tools, and equipment

q. Maintain a daily attendance log of all workers and visitors that includes contact information, including name, phone number, address, and email.

r. Post a notice in an area visible to all workers and visitors instructing workers and visitors to do the following:
    i. Do not touch your face with unwashed hands or with gloves.
    ii. Frequently wash your hands with soap and water for at least 20 seconds or use hand sanitizer with at least 60% alcohol.
    iii. Clean and disinfect frequently touched objects and surfaces such as work stations, keyboards, telephones, handrails, machines, shared tools, elevator control buttons, and doorknobs.
    iv. Cover your mouth and nose when coughing or sneezing, or cough or sneeze into the crook of your arm at your elbow/sleeve.
    v. Do not enter the jobsite if you have a fever, cough, or other COVID-19 symptoms. If you feel sick, or have been exposed to anyone who is sick, stay at home.
    vi. Constantly observe your work distances in relation to other staff. Maintain the recommended minimum six feet at all times when not wearing the necessary PPE for working in close proximity to another person.
    vii. Do not carpool to and from the jobsite with anyone except members of your own household unit, or as necessary for workers who have no alternative means of transportation.
    viii. Do not share phones or PPE.

SECTION 00650

NOTICE TO PROCEED

Date: _____

TO: _____

ADDRESS: _____

PROJECT: _____

You are notified that the Contract Time under the above contract will commence to run on _____. By that date, you are to start performing your obligations under the Contract Documents. In accordance with Section 00600, Construction Agreement, the date of Substantial Completion is _____, and the date for Final Completion is _____.

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

By :_____

Ben Cayabyab
Contracts Manager

END OF DOCUMENT

SECTION 00800

SUPPLEMENTARY GENERAL CONDITIONS

PART 1 - GENERAL

1.1 SCOPE OF WORK

In general, the Work consists of the following, but not limited to: Replacing the existing Andover direct digital control (DDC) systems and Triatek air valves at Los Medanos Science Building with a new ALC Building Automation System (BAS) and AccuValve air valves. See Section 00010, Table of Contents, for a list of all the Contract Documents (specifications) included in this the scope of work, including addendums issued and referenced in the Contractor's bid form (Section 00300).

1.2 REFERENCES

A. The publications listed below form a part of this specification by reference.

1. Current California Occupational Safety and Health Act Regulations
2. Current California Occupational Safety and Health Construction Safety Orders
3. This work will be contracted using the District's Construction Agreement; See Section 00600.

1.3 SUBMITTALS

A. Provide submittals in the format, and as described below:

1. **Submittals shall be submitted to the District, electronically, in PDF format, within fourteen (14) Calendar Days from the Notice to Proceed, except as otherwise noted.**

~~2. N/A~~

3. Submittals that require local and State agency approval, shall conform to this Specification and the requirements of the local or State agency.
4. **District will review and provide a response to submittals within fourteen (14) calendar days (excluding holidays).** Submittals that include design documents prepared by a licensed California Engineer will be submitted for the District's records. Any District review and response to the Contractor's design documents by a licensed California Engineer will be for format and general compliance only. Contractor and Contractor's licensed California Engineer are responsible for compliance with all applicable State of California codes, laws and regulations applicable to this project.

B. Provide submittals for all equipment, if any, listed on the Drawings or in the Specifications.

C. The Schedule of Values shall be submitted to the District within seven (7) calendar days after the Notice of Award. The Schedule of Values shall be broken down by the following minimum categories:

1. Submittals
2. Equipment Procurement
3. Equipment installation
4. Programming
5. Testing and Commissioning
6. Training
7. Owner and Maintenance Manuals and Warranties
8. As-Builts / Project Record Documents

The District will only pay for Work installed at the Site.

D. CPM construction schedule shall be submitted as a Microsoft Project file within **ten (10) calendar days** from the Contract Award date. District and Contractor shall meet and review the schedule. The Notice to Proceed will not be issued until the District accepts the schedule or accepts it with conditional changes. Below are the minimum activity types that shall be included in the schedule:

1. Contractor Submittals
2. Submittal Reviews by District
3. Procurement
4. Construction activities corresponding to the Schedule of Values
5. Substantial Completion Milestone
6. Project Closeout Activities.
7. Final Completion Milestone

E. Submittals are for review of conformance with the requirements of the Contract.

1.4 SUBSTITUTIONS.

A. *One Product Specified.* Unless the Specifications state that no substitution is permitted, whenever the Contract Documents indicate any specific material, product, thing or service, or any specific name, make, trade name, or catalog number, with or without the` words "or equal," such specification shall be deemed to be used for the purpose of facilitating description of the material, product, thing or service desired and shall be deemed to be followed by the words "or equal" unless the Contract Documents specify "no substitution allowed", "no equal", "no equivalent", or other language with similar meaning, in which case no substitutions will be allowed. Pursuant to Paragraph 1.3.F.3, the Contractor may, unless otherwise stated, within three (3) work days after the bid opening, submit a substitution request for any material, product, thing or service, which shall be materially equal or better

in every respect to that so indicated or specified ("Specified Item") and will completely accomplish the purpose of the Contract Documents.

1. *Products Specified which are Commercially Unavailable*. If the Contractor fails to make a request for substitutions for products, within three (3) work days after bid opening, and such products subsequently become commercially unavailable, the Contractor may request a substitution for such commercially unavailable item. The decision to grant this request is solely at the District's discretion. The written approval of the District, consistent with the procedure for Change Orders, shall be required for the use of a proposed substitute material. The District may condition its approval of the substitution upon the delivery to District of an extended warranty or guaranty or other assurances of adequate performance of the substitution as well as an equitable deduction in the contract sum should the substituted item cost less than the Specified Item. All risks of delay due the approval of a requested substitution by the District, DSA, or any other governmental agency having jurisdiction, shall be on the requesting party. All additional costs, all procurement and construction delays, and all costs for review by the Architect or its consultants shall be the responsibility of the Contractor and will be deducted from Contractor's pay request.

B. Substitution Request Form. Requests for substitutions of materials, products, things or services in place of a Specified Item must be submitted to the District in writing on the District's Substitution Request Form ("Request Form") within three (3) work days after bid opening, except as provided for in Paragraph 1.3.F.1.

1. The Substitution Request Form must be accompanied by evidence as to whether the proposed substitution:

   (a) Is equal in quality/service/ability to the Specified Item;
   (b) Will entail no changes in detail, construction, and scheduling of related work;
   (c) Will be acceptable in consideration of the required design and artistic effect;
   (d) Will provide no cost disadvantage to the District;
   (e) Will require no excessive or more expensive maintenance, including adequacy and availability of replacement parts; and
   (f) Will required no change of the construction schedule.

2. In completing the Substitution Request Form, the bidder shall state, with respect to each requested substitution, that the bidder will agree to provide the Specified Item in the event that the District denies the bidder's request for such requested substitution. In the event the District denies the bidder's requested substitution for a Specified Item, the bidder shall provide the Specified Item without any additional cost or charge to the District and waives all rights to submit a claim.

C. After Bid Opening. After bids are opened, the apparent lowest bidder shall provide, within three (3) days of opening such bids, any and all Drawing, Specifications, samples, performance data, calculations, and other information, as may be required to assist the Design Consultant and the District in determining whether the proposed substitution is acceptable. The burden of establishing these facts shall be upon the bidder.

1. After the District's receipt of such evidence by the bidder, the District will make its final decision as to whether the bidder's request for substitution for any Specified Items will be granted. The decision as to whether a proposed request for substitution is equal to a Specified Item shall be at the sole discretion of the District. Any request for substitution that is granted by the District shall be documented and processed through a Change Order. The District may condition its approval of any substitution upon delivery to the District of an extended warranty or guaranty or other assurances of adequate performance of the substitution. Any and all risks of delay due to approval by the District, DSA or any other governmental agency having jurisdiction shall be on the bidder.
2. If the Design Consultant and District accept a proposed substitution, the Contractor agrees to pay for all District expenses, including but not limited to Division of the State Architect fees, engineering and design services, compensation to the Design Consultant for their required time to process such substitution through the Division of the State Architect, if required, and to make all changes and adjustments in materials or the work of all trades directly or indirectly affected by the substituted item or items at no cost to the District

PART 2 - PRODUCTS

2.1 MATERIALS

A. Contractor Provided Materials: The Contractor provided materials shall include any associated equipment and appurtenances required for performing the contract properly and in accordance with the equipment manufacturer's literature.

B. All materials shall be new, unless otherwise authorized or specified in the scope of work of this specification.

PART 3 - EXECUTION AND RELATED REQUIREMENTS

3.1 GENERAL

A. Work Restrictions: Contractor shall maintain a safe path of travel for all pedestrians and vehicles during construction. Contractor is required to provide safety barricades and alternative routes of travel for pedestrians and vehicles at all times, unless otherwise approved by the District. Anytime the Contractor anticipates it will block and divert existing paths of travel for pedestrians or vehicles, it shall provide a hard copy plan along with proposed wayfinding signage for review by the District at least 5 work days prior to such blockage and diversion. Said plan shall be reviewed and approved by the District prior to commencement of this work by the Contractor.

1. From the period of Notice to Proceed until the end of Summer Session classes on July 21, 2022, a number of classrooms will be unavailable for work during normal hours. The list of unavailable classrooms to be issued in Addendum #1.
2. From the Period of July 22, 2022, to August 19, 2022, the building will be unoccupied, and work can occur in all areas during normal business working hours.
    a. All Field Labor inside classrooms must be completed by August 19, 2022.

b. Systems must be functional to allow for occupancy of classrooms starting August 20, 2022.

B. Contractor shall provide barricades, wayfinding signage, safety signage, and COVID-19 signage around the construction site through Substantial Completion to deter access by students, faculty, and the public to areas under the control of the Contractor.

C. Contractor will be allowed to have access and use Campus utilities for temporary water and electricity, but Contractor shall be responsible to investigate prior to bid, and for all work necessary to connect to existing utilities for temporary use.

D. Contractor shall control all construction-generated dust during construction, and clean-up said dust and debris daily to prevent migration to other areas or rooms.

E. Scheduling and Coordination: Before commencing work on a specific area, the Contractor shall confirm that all requirements have been met pertaining to scheduling of the work. The Contractor shall further determine that all required written notices have been given to the District.

F. Scheduling and Sequence of Work: The work shall be prosecuted in such a manner as to cause the least interference with the normal functions of the campus activity in the adjacent areas. Prior to beginning any work, the Contractor shall meet with the District and the Contractor's schedule shall be approved as noted in Article 1.3D above.

G. Interruption of Utilities Services: Interruptions shall be kept to a minimum and shall be at such times and duration as approved ahead of time by the District. No interruption shall occur unless scheduled with the District and approved in advance in writing as to time and duration of such interruption. No utility interruptions that impact building operation during classes will be allowed, and these types of interruptions, if any, shall be scheduled for after normal hours when classes are not in session.

H. Material, equipment, tools and workmen shall be scheduled and delivered to the Site in a timely manner to avoid delay in the work. Materials provided shall be inspected by the Contractor to make certain they follow the specifications and are free from defects and damage.

I. Measurements: Before fabrication, obtain necessary field measurements and verify all measurements.

J. Bathroom Facilities: The Contractor will NOT be allowed to use College bathroom facilities and the Contractor shall provide porta-potties and cleaning stations to wash hands for construction personnel located at the Site. The location shall be approved in writing by the District before locating the porta-potties.

K. Workmanship: Skilled personnel shall execute in a careful, neat, and proficient manner and in compliance with accepted trade practices for all work. All work shall be executed in accordance with Cal/OSHA standards and safety orders. And all work on this contract shall comply with all Local, State, and Federal Environmental Laws.

L. Incidental Work: Minor incidental materials and work not specifically mentioned herein, but necessary for the proper completion of the specified work, shall be provided without additional cost to the District

M. Administrative Forms: District shall provide its standard forms for use by Contractor.

3.2 EXISTING CONDITIONS & DRAWINGS

A. See Section 00210, Information Available to Bidders for documents available for review by the Contractor and its subcontractors prior to and after bid.

3.3 WORK BY CALIFORNIA LICENSED ENGINEER

A. Note that modifications to existing building structures, fire systems, or ADA changes, if any are discovered during construction, will require DSA approval. Contractor will be granted a non-compensable time extension for the duration it takes to obtain DSA approval. A change order will be negotiated for added direct labor field construction costs, if any.

3.4 NOISE CONTROL

A. Noise, Vibration, and Odors: Coordinate operations that may result in high levels of noise and vibration, odors, or other disruption to building occupants.

1. Notify District's Representative not less than two days in advance of proposed disruptive operations.
2. Obtain District's Representative's written permission before proceeding with disruptive operations.

3.5 SITE WORK-Not Used

3.6 PROJECT CLOSEOUT REQUIREMENTS (After Substantial Completion & Before Final Completion)

A. Refer to the Drawings listed in Section 00010, Table of Contents for requirements, and these Supplementary General Conditions.

B. Provide final clean-up of Site prior to Final Completion.

C. Warranty

1. The Contractor warrants to the District that material and equipment furnished under the Contract will be of the highest quality and new unless otherwise required or permitted by the Contract Documents, that the Work will be free from defects not inherent in the quality required or permitted, and that the Work will conform with the requirements of the Contract Documents. Work not conforming to these

requirements, including substitutions not properly approved and authorized, may be considered defective. Contractor's warranty and guaranty to District includes, but is not limited to the following representations:

a. In addition to any other warranties and guaranties provided elsewhere, Contractor shall, and hereby does, warrant all Work after the Certificate of Substantial Completion date issued by District and shall repair or replace any or all such work, together with any other work, which may be displaced in so doing that may prove defective in workmanship or materials within a one (1) year period from date of completion as defined in Public Contract Code Section 7107(c) without expense whatsoever to District, ordinary wear and tear, unusual abuse or neglect excepted. District will give notice of observed defects with reasonable promptness. Contractor shall notify District upon completion of repairs.

b. In the event of failure of Contractor to comply with above mentioned conditions within one week after being notified in writing, District is hereby authorized to proceed to have defects repaired and made good at expense of Contractor who hereby agrees to pay costs and charges therefore immediately on demand.

c. If, in the opinion of the District, defective Work creates a dangerous condition or requires immediate correction or attention to prevent further loss to the District, the District will attempt to give the notice required by this Article. If the Contractor cannot be contacted or does not comply with the District's requirements for correction within a reasonable time as determined by the District, the District may, notwithstanding the provisions of this article, proceed to make such correction or attention which shall be charged against Contractor. Such action by the District will not relieve the Contractor of the guarantee provided in this Article or elsewhere in this Contract.

d. This Article does not in any way limit the guarantee on any items for which a longer warranty or guaranty is specified in the **technical specifications** or on any items for which a manufacturer gives a guarantee for a longer period. Contractor shall furnish District all appropriate guaranty or warranty certificates upon completion of the project.

2. Format - All Warranties/Guaranties and shall include:

   a. Contractor, subcontractor, and equipment supplier shall provide Warranties and Guaranties on their original company letterhead with original signature.

   b. Contractor shall provide original Warranties and Guaranties. Photocopies, fax and e-mail copies are not acceptable.

3. Preparation

   a. Contractor shall obtain warranties and guaranties, executed in duplicate by each applicable and/or responsible subcontractor(s)**,** supplier(s), and manufacturer(s), within fifteen (15) days after Certificate of Substantial Completion date of the applicable Work. **Contractor shall leave date of beginning of time of warranty or guaranty blank until the date of Final Completion is determined by District as detailed in the Technical Specifications.**

b. Contractor's Response to Construction Warranty and Guaranty Service Requirements: Following oral or written notification by the District, respond to construction warranty and guaranty service requirements within 24 hours, or earlier in case of emergency.

4. Warranty and/or Guaranty Tags

a. At the time of installation of mechanical equipment or other major system elements, tag each warranted or guaranteed item with a durable, oil and water-resistant tag approved by the District. Attached each tag with a copper wire and spray with a silicone waterproof coating. The date of Substantial Completion and the Contractor Authorized signature must remain blank until the date the District makes a determination of Substantial Completion. Show the following information on the tag:

WARRANTY/GUARANTY INFORMATION – [insert project number and name on actual tag]

a. Type of product/material_____.
b. Model number_____.
c. Serial number_____.
d. Contract number_____.
e. Warranty/Guaranty period _____ (months) from_____ to_____.
f. Inspector's signature .
g. Construction Contractor_____.
   Address_____.
   Telephone number_____.
h. Warranty or Guaranty contact_____.
   Address_____.
   Telephone number_____.
i. WARNING - PROJECT PERSONNEL TO PERFORM ONLY OPERATIONAL MAINTENANCE DURING THE WARRANTY PERIOD.

3.7 Project As-Built

A. Contractor shall dedicate one complete full-size set of the Contract Drawings and one complete Project Manual for use in documenting as-built conditions, including but not limited to; RFIs, ASI, PCOs and Change Order.

B. Contractor shall submit to District in hard copy one original and two copies of all Project As-Built Documents. In addition, one electronic copy shall be submitted to District. District reserves the right to require resubmittal in accordance with these Supplementary General Conditions if the documents are inaccurate or incomplete, or otherwise fail to meet the requirements of these Contract Documents.

C. Electronic Media Format: Electronic media format for all Project As-Built Documents shall be Adobe PDF, with chapter markers and/or bookmarks inserted in place of the equivalent hard copy section tabs. Electronic copy shall include all tables, charts, drawings, codes and all other matters reflected in hard copies. Electronic media files shall be delivered on a unique CD-ROM or flash drive.

3.8 TIME OF COMPLETION

A. See Section 00300, Bid Proposal Form for specific requirements to complete the Work. Time requirements are also included in Section 00600, Construction Agreement.

B. Substantial Completion: The date on which the Work or designated portion thereof, as certified by the District and Architect, is sufficiently complete, in accordance with the Contract Documents, so the District may occupy or utilize the Work or designated portion thereof for the use for which it is intended.

C. Remaining Work after Substantial Completion: If the Architect or District determines that the work required by the Contract is Substantially Complete during any inspection conducted pursuant to this Agreement, the Contractor shall be notified of that determination and the District shall determine if there is Remaining Work. A list of Remaining Work shall be issued only by the District or the Architect and only after the District has certified Substantial Completion. The District or Architect shall give the Contractor the necessary instructions for correction or completion of the Remaining Work, and the Contractor shall immediately comply with and execute such instructions within the Contract Time. Upon completion of the Remaining Work, another inspection shall be made that shall constitute the Final Inspection, provided the Remaining Work has been completed to the satisfaction of the District. If the remaining work has been completed to the satisfaction of the District, the District shall make the final acceptance and notify the Contractor in writing of this acceptance as of the date of Final Inspection.

D. Final Completion: The date when all Work for the total project has been completed in accordance with the terms of the Contract Documents and has been inspected following completion of Work identified in the Punch List Inspection and accepted by the Architect and the District. Final Completion is also sometimes referred to as Final Acceptance.

3.9 ADDITIONAL REQUIREMENTS FOR DSA-APPROCED PROJECTS

A. All substitutions affecting DSA regulated items shall be considered as a Construction Change Document or Addenda and shall be approved by DSA prior to fabrication and installation, as required by IR A-6 and Section 4-338(c), Part 1. Substitutions shall be for any material, system or product that would otherwise be regulated by DSA.

B. All Addenda must be signed by **Engineer of Record** and approved by DSA (Section 4-338, Part 1).

C. The Construction Change Documents (Section 4-338(c), Part 1) must be signed by all the following:

1. A/E of Record
2. Structural Engineer (when applicable)
3. Delegated Professional Engineer (when applicable)
4. DSA

Contra Costa Community College District
pathways to success

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

500 Court Street, Martinez, CA 94553

SUBSTITUTION REQUEST FORM

RFS # _____ Date: _____

Contractor Name: _____

Contract #:

DSA Application #: _____

Campus: Contra Costa College

Project No., Name: _____

Contractor pursuant to General Conditions submits the proposed items. If the District accepts such items so described, the undersigned may furnish such item with all necessary labor, materials, equipment and incidentals to perform and complete the Work.

Item No.	SPECIFIED ITEM OR DRAWING	SPECIFICATION SECTION	PROPOSED SUBSTITUTION (and name of Subcontractor if different)

CERTIFICATION

Under penalty of perjury under the Laws of California, I certify that the proposed substitution will be readily available, perform adequately the functions and achieve the results called for by the design concept, be similar in substance to that specified, and be suited to the same use as that specified in Contract Documents.

Contractor: _____ _____ _____

(Please print name of company) Name and Title (print/type) Contractor Authorized Representative Date

A. Does the substitution affect dimensions shown on Drawings?

B. Will the undersigned pay for changes to the building design, including engineering and detailing costs caused by the requested substitution?

C. What effect does the substitution have on other trades?

D. Will substitution cause change to Project Schedule, or to critical delivery dates? Add ? Shorten ?

E. Differences between proposed substitution and specified item?

F. What is the Cost Differential including all mark-ups?

G. Are Manufacturer's guarantees for the proposed item the same as for item specified? Explain differences.

H. The undersigned accepts full responsibility for delays caused by redesign of other items of the Work necessitated by substitution.

I. The undersigned states that the function, appearance and quality are equivalent or superior to the specified item.

A/E Response:	District Representative Response:
O Accepted	O Accepted
O Not Accepted	O Not Accepted
O Accepted As Noted	O Accepted As Noted
O Received Too Late	O Received Too Late
BY:_____ Date:_____	By:_____ Date: _____

END OF SECTION 00800

SECTION 250000

BUILDING AUTOMATION SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. This project consists of replacing the existing Andover direct digital control (DDC) systems and Triatek air valves at Los Medanos Science College (LMC) Building with a new ALC Building Automation System (BAS) and AccuValve air valves.

B. The purpose of the replacement is to replace obsolete control equipment and upgrade to state-of-the-art systems that meet current Contra Costa Community College District (4CD) standards, including optimized control sequences based on ASHRAE Guideline 36.

C. Work Excluded

1. Cost of repairing existing equipment that is specified to be reused, if required.

2. Fire Alarm Systems (FAS). The existing FAS in the building is separate from the existing BAS and shall remain independent with existing interlocks to remain as-is.

3. Integration with existing lighting controls.

1.2 CONTRACTOR PROPOSALS

A. Contractor shall visit site prior to bid. Ascertain and check all conditions and take all measurements that may affect the work. No allowance shall subsequently be made for any additional expenses or claims due to the failure or neglect under this Section to make such examination, including examination of restricted working conditions or such other difficulties that can be visually observed during site visit.

B. The system requirements described in this specification are generally performance based. Where requirements are prescriptive, the intent is to provide minimum quality, not to give unfair advantage to any given manufacturer or product. If a contractor finds that a certain requirement is unduly difficult or expensive to meet, contact the Engineer prior to bid due date and an addendum modifying the requirement will be considered.

C. Original design drawings provided as part of the bid package do not represent as-built conditions. All conditions should be field verified.

D. Where requirements are unclear, the contractor shall clarify the requirements with the Engineer before the bid due date. Where requirements continue to be unclear, the contractor's proposal must accurately describe what is included and excluded.

E. By submitting a proposal, contractor guarantees that their proposal is in full compliance with these specifications and is complete and turnkey, except where specific exceptions are provided herein or clearly noted in the contractor's proposal.

F. Include any charges, including overtime wages, required to perform work within scheduling criteria and use-of-premises restrictions specified in Paragraph 1.4.

G. Bid proposals shall include:

1. Completed bid form, including breakout pricing. Breakout pricing shall include overhead, profit, installation, programming, commissioning, etc.; it may be approximate and is for info only.

2. Proposed construction schedule. The proposed date of completion will be a factor in contractor selection. Include details that indicate the use-of-premises restrictions specified in Paragraph 1.4 have been taken into account.

3. Any clarifications and exceptions to these specifications.
   a. Do not exclude work that is required – this is a turn-key project with no other prime Contractors involved. BAS Contractor shall serve as the prime Contractor and hire subcontractors as required.

H. Alternate Pricing. Alternate prices shall include all equipment, material, labor, design engineering, balancing, start-up and testing costs necessary to provide a complete operational system. Provide a separate price for each alternate.

1. ARCnet for Primary LAN. The base bid shall be based on ALC's IP controllers for ASCs and AACs, including VAV zones. For this alternate assume ARCnet and ZN line and ME/SE line controllers may be used with new twisted pair network cabling. If contractor does not wish to use ARCnet, this alternate need not be priced.

2. Onsite Virtual Server. The base bid shall be based on using the existing ALC server located on the Brentwood campus to serve as the CSS for this project. For this alternate, include all required server software configured on a virtual server (provided by LMC) located in the main MDF on the LMC campus, configured in a hierarchical arrangement serving as the "parent" with the existing Brentwood server serving as the "child". Alarms shall be configured to propagate between systems.
   a. Fully comply with ALC procedures, e.g.

      To set up the parent system
      (/alc/s/knowledge/article/SiteBuilderv65FindInfo-8203)

      To set up a child system
      (/alc/s/knowledge/article/SiteBuilderv65FindInfo-39148)

      To finish setting up your hierarchical system
      (/alc/s/knowledge/article/SiteBuilderv65FindInfo-25089)

3. VFD Integration. The base bid does not include integration of VFDs to the ALC system, as they are not integrated to the existing Andover system. For this alternate, provide BACnet MS/TP network to VFD interfaces (assumed to exist or provided by others), map points via BACnet, and provide graphics of VFD data and hyperlinks on associated graphics as specified herein. VFDs include:
   a. Cooling tower fan
   b. CHW pump
   c. AH-2 and 3 fans
   d. AC-1 fans
   e. EF-1 and 2 fans

4. Reuse VAV and Lab Zone Reheat Coil Valves. The base bid includes at least new analog actuators on zone HW valves (valve bodies may be reused or replaced at contractor's option). For this alternate, reuse the existing valves and actuators.

5. Add DCW multi-jet flow meters. The base bid does not include domestic water meters. For this alternate, provide FM-6 multi-jet flow meters with pulse output at:
   a. 4" main in Plumbing Equipment Room 123
   b. 1.5" main to Chiller Room

6. Add DCW magnetic flow meters. The base bid does not include domestic water meters. For this alternate, provide FM-1 full bore magnetic flow meters with pulse output at:
   a. 4" main in Plumbing Equipment Room 123
   b. 1.5" main to Chiller Room

7. Add natural gas meter. The base bid does not include natural gas meter. For this alternate, provide a FM-3B meter with pulse output locate in the Plumbing Equipment Room 123 mounted in the existing 2 inch low pressure gas line.

8. No CAD files. The base bid assumes that architectural drawings will be available in CAD format for use in graphics. For this alternate, assume that the only drawings available are the pdf files included in the Bid Package.

9. VAV box calibration unit price (cost per VAV box). The base bid does not include calibrating VAV reheat boxes; the ALC default coefficients will be used based on box inlet size. For this alternate, the Contractor shall inspect VAV box inlet conditions during controller installation and tag those that do not have at least 1½ times the inlet duct diameter of straight duct at the VAV box inlet. (A concentric reducing taper with maximum 15° angle shall qualify as straight duct.) For those zones that do not meet this criterion, adjust BAS calibration constants so that the VAV box controller and measured air flow rate at air outlets matches the ALC reading within range listed at all of the following conditions:
   a. Maximum airflow setpoint, ±5%
   b. Controllable minimum airflow setpoint, ±10%. The controllable minimum value shall be that determined under Section 259000.
   c. Zero flow

1.3 INTEGRATION WITH EXISTING SYSTEM

A. This section applies to the base bid option of using the existing Brentwood server.

B. Include all services required to integrate this building into existing BAS for a fully operational system.

C. Procedure

1. Obtain a copy of the campus database with access privileges.

2. BACnet devices
   a. Create new building database following the BACnet device instance numbering scheme specified under Paragraph 3.12B.4.
   b. Double check existing database to ensure there are no duplicate BACnet device instance numbers. This includes 3rd party equipment such as VFDs.

3. Graphics
   a. Upgrade all graphics to the latest 4CD standard graphics file template, including using the same file template name. See sample graphics herein. Also refer to the graphics used for the CCC Science Building.
   b. For new or modified graphics custom to the new building, ensure file template name do not duplicate any existing file names.

4. Programming
   a. For standard sequences covered by ASHRAE Guideline 36, use the programming provided by Automated Logic, first ensuring they have been updated by the manufacturer to reflect the latest issue and all addenda published when programming work is initiated.
   b. For other typical applications, first review those used for similar applications in other campus buildings to use as a starting point, then edit to reflect sequences specified herein. The intent is to have standard programming throughout the campus to the extent possible.
   c. Double check existing database to ensure program file names do not duplicate any existing file names.

5. If a BACnet/IP Broadcast Management Device (BBMD) router is required, check the existing Broadcast Distribution Tables (BDT) to ensure that a BBMD router is not already assigned to the relevant network before adding a new one.

6. Install building database and control programming on a temporary portable operator's terminal provided by the Contractor. The POT shall be used for start-up, testing, and commissioning. The POT shall remain the property of the Contractor after final completion of the project.

7. Once the building BAS has been fully commissioned and accepted by the College:
   a. Create a new backup of the existing campus database.
   b. Merge the new building database with the existing campus database.
   c. Confirm that no communication issues (in the building and across the campus) have resulted from the merge.
   d. Make another backup of the merged database.
   e. Load the merged database onto the campus Control System Server.

f. Integrate graphic screens into the Central Plant graphics including adding appropriate hyperlinks so that the system operates as one integrated system.
g. Confirm that the merge was successful by sample testing points and sequences
h. Receive College approve of the final installation in writing.

8. Provide high level password for College operator access to the system only at this point; College will not have access to the system prior to system acceptance and integration.

1.4 USE OF PREMISES

A. BAS Contractor shall become fully informed of, and shall fully comply with, College's site security requirements and provisions.

B. BAS Contractor shall limit the storage of materials and equipment on-site to specific areas approved by the College. The College may also limit the type of material stored. At no time during the work under the contract shall the BAS Contractor place, or cause to be placed, any material or equipment at any location that would impede or impair access to or from the present facilities.

C. BAS Contractor shall send proper notices, make all necessary arrangements, and perform all services required in the care and maintenance of building utilities to the extent that these utilities may be affected and/or interrupted by the BAS installation work. Building utilities include telephone / telecommunications, electrical service, natural gas, central heating and cooling, water, and other utilities necessary for building operation and occupant comfort.

D. All work that has the potential for interrupting building usage, utilities, and/or maintenance services shall be scheduled to occur during evenings and/or weekends and coordinated with the College. This includes cutting and drilling work from which dissipated noise and vibration may impact the normal work of building occupants.

E. Work Schedule. The building will remain operational during construction, but some areas may be shut down as indicated in this Paragraph and the preliminary schedule provided with the Bid Package. Changes to systems that affect building operations must be minimal in impact and time out-of-service. The functions of the existing BAS must be migrated in a manner that keeps all systems operational throughout the duration of this work. All down-times must be scheduled at least a week in advance with approval of the College project manager.

1. The building will be unoccupied from July 22-August 19, 2022. All work during this period may be during normal working hours. Outside this period, the Contractor will need to work with the College to find times when individual rooms are unoccupied during normal hours, or the work must be executed during off-hours.

2. Air distribution systems serving classroom, offices, public spaces etc. shall be operational during normal business hours, except:

a. Zonal systems may be shut off when rooms are scheduled to be unoccupied, even during normal business hours. Coordinate when rooms are scheduled to be unoccupied with the College project manager.
b. AHUs may be shut off for occasional periods not exceeding 15 minutes and shall be operational for at least 45 minutes between outages.

3. Air distribution systems serving lab spaces with hoods shall be operational 24/7 except during scheduled unoccupied hours, when scheduled in advance with the College project manager, with following procedures:
   a. Doors to labs shall be opened (for makeup air).
   b. Hood sashes shall be closed.
   c. Hood exhaust may be shut off for no more than 30 minutes with at least 60 minutes between outages.
   d. Lab general exhaust shall be overridden closed.
   e. Lab exhaust fans shall continue to operate automatically. When lab exhaust fan controls are replaced, keep at least one fan operating continuously.

4. Chilled water plant shall be operational during normal business hours, except it may be shut off for occasional periods not exceeding 15 minutes and shall be operational for at least 45 minutes between outages. It may be shut off at any time when outdoor air temperature is less than 60ºF.

1.5 REUSE OF EXISTING SYSTEMS AND EQUIPMENT

A. Unless otherwise directed, the Controls Contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators that are designated to be reused. Should the Contractor find existing equipment that requires maintenance, the College shall be notified immediately.

B. Note that phasing may be required to meet use-of-premises restrictions specified in Paragraph 1.4, which in turn may affect the ability to reuse equipment, such as control panels, control wiring etc.

C. Wiring and Raceway

1. All existing control conduit may be reused.

2. All Supervisory and Primary LAN wiring shall be new. Secondary LAN wiring may be reused at contractor’s option.

3. Control wiring to controlled devices (e.g. actuators, VFDs), sensors (e.g. temperature) etc. may be reused:

4. Where wiring is reused, its integrity and suitability to the new application is the responsibility of the Contractor. Wiring shall be properly identified and tested. The cost to replace/repair defective wiring is outside the scope of this proposal.

5. Unused or redundant wiring and conduit shall be removed.

D. Temperature Sensors

1. Existing temperature sensors shall be replaced, except as specifically indicated in the Control Points section or this section.

2. Existing wells in piping for temperature sensors may be reused.

E. Other Sensors

1. Reuse existing sensors unless specifically called out to be new in Control Points lists.

F. Temperature Control Panels

1. The Contractor may reuse any existing local control panels to locate new equipment.

2. Controllers and other analog devices shall not be reused unless specifically called out to be new in Control Points lists.
   a. Salvage all Andover controllers in TCPs and return to College so that they might be reused on other existing buildings.

3. Power supplies, transformers, UPS, disconnect switches, and relays may be reused.

4. All unused existing equipment within these panels must be removed and shall not be reused.

5. All no longer used panels shall be demolished.

G. Starters and Variable Speed Drives

1. Reuse existing; repair of same is not part of this project.

2. Connect BACnet MS/TP to existing VFDs as an Alternate Bid only; see Paragraph 1.2H.3.)

H. Air Handling Units

1. AHU dampers may be reused.

2. All damper actuators shall be replaced.

3. Existing control valve bodies may be reused.

4. All valve actuators shall be replaced.

5. Airflow measuring stations shall be added or replaced.

I. VAV Zones

1. Demo the following:
   a. Damper actuator and controller
   b. Thermostat and associated wiring

c. Discharge air temperature sensor
d. HW Valve actuator

2. The following may be reused:
a. VAV boxes and velocity pressure flow cross/ring
b. Transformers and power wiring
c. Control wiring where applicable and not shown to be demoed
d. Reheat coils and HW valve bodies

3. The following shall be new:
a. VAV controllers with integral actuators
b. Wall thermostats in existing location with new cable to zone controller
c. HW valve actuators

J. Lab Zones

1. Demo the following:
a. Air valves (supply, hood exhaust, general exhaust) and controllers
b. HMS Hood monitors and associated wiring
c. Hood sidewall sensors and associated wiring
d. Hood sash position sensors and associated wiring
e. Thermostat and associated wiring
f. Discharge air temperature sensor
g. HW Valve actuator

2. The following may be reused:
a. Hood ZPS presence sensors
b. Transformers and power wiring
c. Control wiring where applicable and not shown to be demoed
d. Reheat coils and HW valve bodies

3. The following shall be new:
a. AccuValve air valves with integral actuator and controller
b. Hood monitors and associated wiring
c. Hood sash position sensors and associated wiring
d. Wall thermostats in existing location with new cable to zone controller
e. HW valve actuators

K. Safeties and Fire Alarm Controls

1. The fire alarm system (FAS) is an independent system and not a part of this project.

2. Existing safeties in control circuits (duct smoke detectors, life safety system interlocks) are not to be bypassed and are to remain functional at all times during and after construction.

L. Instrumentation. Existing pressure gauges and thermometers on pumps, boilers, etc. are to remain as-is; repair or calibration of same are not part of this project.

1.6 REFERENCE STANDARDS

A. Nothing in Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, and regulations. When Contract Documents differ from requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.

B. The latest published or effective editions, including approved addenda or amendments, of the following codes and standard shall apply to the BAS design and installation as applicable.

C. State, Local, and City Codes

1. CBC − California Building Code

2. CMC − California Mechanical Code

3. CEC – California Electrical Code

4. Local City and County Codes

D. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

1. ANSI/ASHRAE 135 – BACnet - A Data Communication Protocol for Building Automation and Control Networks

2. ANSI/ASHRAE Standard 135.1− Method of Test for Conformance to BACnet

3. ANSI/ASHRAE Standard 15 – Safety Standard for Refrigeration Systems

E. Electronics Industries Alliance

1. EIA-232 – Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

2. EIA-458 – Standard Optical Fiber Material Classes and Preferred Sizes.

3. EIA-485 – Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.

4. EIA-472 – General and Sectional Specifications for Fiber Optic Cable.

5. EIA-475 – Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.

6. EIA-573 – Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.

7. EIA-590 – Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.

F. Underwriters Laboratories

1. UL 916 – Energy Management Systems.

G. National Electrical Manufacturers Association

1. NEMA 250 – Enclosure for Electrical Equipment.

H. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 142 – Recommended Practice for Grounding of Industrial and Commercial Power Systems.

2. IEEE 802.3 – CSMA/CD (Ethernet – Based) LAN.

3. IEEE 802.4 – Token Bus Working Group (ARCnet – Based) LAN.

1.7 DEFINITIONS

A. Acronyms

AAC	Advanced Application Controller
AH	Air Handler
AHU	Air Handling Unit
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
ASC	Application Specific Controllers
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
A-to-D	Analog-to-Digital
BACnet	Data Communications Protocol for Building Automation and Control Systems
BC	Building Controller
BIBB	BACnet Interoperability Building Blocks
BTL	BACnet Testing Laboratory
CAD	Computer Aided Drafting
CHW	Chilled Water
CHWR	Chilled Water Return
CHWS	Chilled Water Supply
COV	Change of Value
CSS	Control Systems Server
CU	Controller or Control Unit
CV	Constant Volume
CW	Condenser Water
CWR	Condenser Water Return
CWS	Condenser Water Supply
DBMS	Database Management System
DDC	Direct Digital Control
DHW	Domestic Hot Water

DI	Digital Input
DO	Digital Output
D-to-A	Digital-to-Analog
BAS	Building Automation System
EMT	Electrical Metallic Tubing
EP	Electro-Pneumatic
ETL	Edison Testing Laboratories
GUI	Graphical User Interface
HHD	Hand Held Device
HOA	Hand-Off-Automatic
HVAC	Heating, Ventilating and Air-Conditioning
HTTP	Hyper-Text Transfer Protocol
I/O	Input/output
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
LAN	Local Area Network
LANID	LAN Interface Device
MAC	Medium Access Control
MHz	Megahertz
MS/TP	Master-Slave/Token-Passing
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
ODBC	Open Database Connectivity
OI	Operator Interface
OWS	Operator Workstation
P	Proportional
PC	Personal Computer
PI	Proportional-Integral
PICS	Protocol Implementation Conformance Statement
PID	Proportional-Integral-Derivative
POT	Portable Operators Terminal
PTP	Point-to-Point
RAM	Random Access Memory
SOO	Sequence of Operation
SQL	Standardized Query Language
SSL	Secure Socket Layers
TAB	Test, Adjust, and Balance
TDR	Time Delay Relay
UFT	Underfloor Fan Terminal Box
UL	Underwriters' Laboratories, Inc.
XML	Extensible Markup Language

B. Terms

Term	Definition
Accessible	Locations that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials. Examples include inside mechanical rooms, mechanical equipment enclosures, instrument panels, and above suspended ceilings with removable tiles.
BACnet Interoperability Building Blocks	A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device in a specification.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.
Change of Value	An event that occurs when a digital point changes value or an analog value changes by a predefined amount.
Client	A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.
Concealed	Embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.
Continuous Monitoring	A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).
Contract Documents	Specifications, drawings, and other materials provided with request for bids.
Control Systems Server	A computer(s) that maintain(s) the systems configuration and programming database.
Controller	Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.
Direct Digital Control	Microprocessor-based control including Analog/Digital conversion and program logic.
Building Automation System	The entire integrated building management and control system.
Equal	Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.
Exposed	Not installed underground or concealed.
Furnish	To purchase, procure, acquire and deliver complete with related accessories.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
Hand Held Device	Manufacturer’s microprocessor based portable device for direct connection to a field Controller.

Term	Definition
Inaccessible	Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.
Indicated, shown or noted	As indicated, shown or noted on drawings or specifications.
Install	To erect, mount and connect complete with related accessories.
Instrumentation	Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the BAS.
College IT LAN	The Information Technology local area network furnished by the College, used for normal business-related communication and may be used for interconnecting some BAS controllers and gateways where specified.
LAN Interface Device	Device or function used to facilitate communication and sharing of data throughout the BAS.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
Motor Controllers	Starters, variable speed drives, and other devices controlling the operation of motors.
Native BACnet Device	A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.
Native BACnet System	A network composed only of Native BACnet Devices without gateways.
Open Database Connectivity	An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.
Open Connectivity	OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.
Operator Interface	A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.
Operator Workstation	The user’s interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.
College	The College or their designated representatives.

Term	Definition
Piping	Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.
Points	All physical I/O points, virtual points, and all application program parameters.
Point-to-Point	Serial communication as defined in the BACnet standard.
Portable Operators Terminal	Laptop PC used both for direct connection to a controller and for remote dial up connection.
Primary LAN	High speed, peer-to-peer controller LAN connecting BCs, AACs, and ASCs as well as some gateways. See System Architecture below.
Protocol Implementation Conformance Statement	A written document that identifies the particular options specified by BACnet that are implemented in a device.
Provide	Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.
Protocol Translator	A device that converts BACnet from one network protocol to another.
Reviewed, approved, or directed	Reviewed, approved, or directed by or to College's Representative.
Router	A device that connects two or more networks at the network layer.
Secondary LAN	LAN connecting some gateways and networked sensors. See System Architecture below.
Server	A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
Standardized Query Language	SQL - A standardized means for requesting information from a database.
Supervisory LAN	Ethernet-based LAN connecting Primary LANs with each other and OWSs, CSS, and THS. See System Architecture below.
Supply	Purchase, procure, acquire and deliver complete with related accessories.
Wiring	Raceway, fittings, wire, boxes and related items.
Work	Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

1.8 QUALITY ASSURANCE

A. Materials and Equipment

1. Manufacturer's Qualifications: See 2.1 for approved manufacturers.

B. Installer

1. The following are approved BAS contractors:
   a. Air Systems. Marina Pelosi Marina.Pelosi@airsystemsinc.com
   b. Sunbelt. Andy Bruch abruch@sunbeltcontrols.com
   c. ASG: Tony Skibinski tskibinski@asgbms.com

2. BAS Contractor's Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 projects of similar size and complexity. Project Manager must have proof of having successfully completed the most advanced training offered by the manufacturer of the proposed product line.

3. BAS Contractor's Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.

4. BAS Contractor's Lead Installation Technician Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system installation for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Installers must show proof of having successfully completed the installation certification training offered by the vendor of the proposed product line.

5. BAS Contractor's Service Qualifications: The installer must be experienced in control system operation, maintenance and service. BAS Contractor must document a minimum 5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.

6. Installer's Response Time and Proximity
   a. Installer must maintain a fully capable service facility within 50 miles of the subject Project. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
   b. Installer must demonstrate the ability to meet the emergency response times listed in Paragraph 1.14B.1.

7. Electrical installation shall be by manufacturer-trained electricians
   a. Exception: Roughing in wiring and conduit and mounting panels may be subcontracted to any licensed electrician.

1.9 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the College's Representative.

B. Submittal Schedule: Submittal schedule shall be as follows unless otherwise directed by the College's Representative:

1. Allow 10 working days for approval, unless College's Representative agrees to accelerated schedule.

2. Submittal Package 0 (Qualifications) shall be submitted with bid.

3. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by the College in bid documents.

4. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.

5. Submittal Package 3 (Pre-Functional Test Forms) shall be submitted no less than 30 days prior to conducting tests.

6. Submittal Package 4 (Pre-Functional Test Report) shall be submitted no less than 14 after conducting tests.

7. Submittal Package 5 (Post-Construction Trend Points List) shall be submitted 14 days prior to the start of the trend collection period.

8. Submittal Package 6 (Functional Test Report) shall be submitted no more than 7 days after conducting tests.

9. Submittal Package 7 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.

10. Submittal Package 8 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation.

C. Submission and Resubmission Procedure

1. Pre-Submittals. Electronic submittals indicated below shall be submitted unofficially via email directly to the Engineer for review and comment prior to formal submission. Comments provided by the Engineer are not official and may be changed or additional comments may be provided on the formal submittal. The intent of pre-submittals is to reduce paperwork and review time.

2. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as SUBMITTAL 250000-01.

3. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 250000-01 REVISION 1.

4. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.

5. Submittals shall have bookmarks for each subsection (e.g. Materials, Drawings) and for each drawing including drawing number and name.

6. College's Representative will return a memo or mark-up of submittal with comments and corrections noted where required.

7. Make corrections
   a. Revise initial submittal to resolve review comments and corrections.
   b. Clearly identify resubmittal by original submittal number and revision number.
   c. The cover page of resubmittals shall include a summary of prior comments and how they were resolved in the resubmittal.
   d. Indicate any changes that have been made other than those requested.

8. Resubmit revised submittals until no exceptions are taken.
   a. The cost of the Engineer's review of submittals after the second resubmittal will be borne by Contractor at Taylor Engineering standard billing rates.

9. Once submittals are accepted with no exceptions taken, provide
   a. Complete submittal of all accepted drawings and products in a single electronic file.
   b. Photocopies or electronic copies for coordination with other trades, if and as required by the General Contractor or College's Representative.

D. Submittals Packages

1. Submittal Package 0 (Qualifications)
   a. Provide Installer and Key personnel qualifications as specified in Paragraph 1.8B.
   b. Format: Word-searchable format per Paragraph 1.10C.3.

2. Submittal Package 1 (Hardware and Shop Drawings)
   a. Hardware
      1) Organize by specification section and device tags as tagged in these specifications.
      2) Do not submit products that are not used even if included in specifications.
      3) Include a summary table of contents listing for every submitted device:
         a) Tab of submittal file/binder where submittal is located
         b) Device tag as tagged in these specifications (such as TS-1A, FM-1)
         c) Specification section number (down to the lowest applicable heading number)
         d) Whether device is per specifications and a listed product or a substitution
         e) Manufacturer
         f) Model number
         g) Device accuracy (where applicable)

h) Accuracy as installed including wiring and A/D conversion effects (where applicable)

4) Submittal shall include manufacturer's description and technical data, such as performance data and accuracy, product specification sheets, and installation instructions for all control devices and software.
5) When manufacturer's cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the Project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.
6) A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.
7) Format: Word-searchable format per Paragraph 1.10C.3.

b. Shop Drawings
1) System architecture one-line diagram indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate address and type for each control unit. Indicate media, protocol, baud rate, and type of each LAN.
2) Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. The schematics provided on Drawings shall be the basis of the schematics with respect to layout and location of control points.
3) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
4) Label each input and output with the appropriate range.
5) Device table (Bill of Materials). With each schematic, provide a table of all materials and equipment including:
a) Device tag as indicated in the schematic and actual field labeling (use tag as indicated in these specifications where applicable and practical)
b) Device tag as indicated in these specifications where applicable and if it differs from schematic device tag
c) Description
d) Proposed manufacturer and model number
e) Range
f) Quantity
6) With each schematic or on separate valve sheet, provide valve and actuator information including pipe size, valve size, C_v, design flow, target pressure drop, actual design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of fail-safe valves and dampers.
7) Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

8) Details of control panels, including controllers, instruments, and labeling shown in plan or elevation indicating the installed locations.
9) Floor plans: None required.
10) Format
    a) Sheets shall be consecutively numbered.
    b) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
    c) Table of Contents listing sheet titles and sheet numbers.
    d) Legend and list of abbreviations.
    e) Schematics
        1. Word searchable pdf format.
        2. 21 inch x 15 inch or 17 inch x 11 inch.

c. Do not include sequence of controls on shop drawings or equipment submittals; they are included in Submittal Package 2.

3. Submittal Package 2 (Programming and Graphics)
    a. A detailed description of point naming convention conforming to Paragraph 3.12B to be used for all software and hardware points, integrated with existing database convention.
    b. A list of all hardware and software points identifying their full text names, device addresses and descriptions.
    c. Control Logic Documentation
        1) Submit control logic program listings (graphical programming) consistent with specified English-language Sequences of Operation for all control units.
        2) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.
        3) Include a MS Word file of the specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. Also merge Guideline 36 sequences, where referenced, verbatim into the file; see Section 259000 Building Automation Sequences of Operation. SOO shall be fully consistent with the graphical programming.
        4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.
        5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.
    d. Graphic screens of all required graphics, provided in final colors.
    e. Format
        1) Points list: Word-searchable format per Paragraph 1.10C.3.
        2) Programming: Native ALC Eikon.
        3) Control sequences: MS Word
        4) Programming and operating manual: Word-searchable format per Paragraph 1.10C.3.
        5) Graphics: Graphical electronic format (pdf, png, etc.).

4. Submittal Package 3 (Pre-Functional Test Forms)
    a. Provide pre-functional test forms as required by Paragraph 3.15B.2.a.

b. Format: Word-searchable format per Paragraph 1.10C.3.

5. Submittal Package 4 (Pre-Functional Test Report)
   a. Provide Pre-Functional Test Report as required by Paragraph 3.15B.2.
   b. Format: Word-searchable format per Paragraph 1.10C.3.

6. Submittal Package 5 (Post-Construction Trend Points List)
   a. Provide a list of points being trended along with trend interval or change-of-value per Paragraph 3.15E.2.d.
   b. Format: See Paragraph 2.12C.3.

7. Submittal Package 6 (Functional Test Report)
   a. Provide completed functional test forms as required by Paragraph 3.15C.4.
   b. Format: Word-searchable format per Paragraph 1.10C.3.

8. Submittal Package 7 (Training Materials)
   a. Provide training materials as required by Paragraph 3.16.
   b. Format: Word-searchable format per Paragraph 1.10C.3.

9. Submittal Package 8 (Post-Construction Trend Logs)
   a. Provide trend logs as required by Paragraph 3.15E.
   b. Format: See Paragraph 2.12C.3.

1.10 COMPLETION REQUIREMENTS

A. Procedure

1. Until the documents required in this Section are submitted and approved, the system will not be considered accepted and final payment to Contractor will not be made.

2. Before requesting acceptance of Work, submit one set of completion documents for review and approval of College.

3. After review, furnish quantity of sets indicated below to College.

B. Completion Documents

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per Paragraph 1.10C.
   a. Include the as-built version of all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual. Submittal data shall be located in tabs along with associated maintenance information.
   b. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

c. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.
d. A list of recommended spare parts with part numbers and suppliers.
e. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
f. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.
g. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.
h. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.
i. English language control sequences updated to reflect final programming installed in the BAS at the time of system acceptance. See Section 259000 Building Automation Sequences of Operation.

2. Complete original issue electronic copy for all software provided, including operating systems, programming language, operator workstation software, and graphics software.

3. Complete electronic copy of BAS database, user screens, setpoints and all configuration settings necessary to allow re-installation of system after crash or replacement of server, and resume operations with the BAS in the same configuration as during College sign-off.

4. Project Record Drawings
   a. As-built versions of the submittal drawings in reproducible paper and electronic format per Paragraph 1.10C.
   b. As-built network architecture drawings showing all BACnet nodes including a description field with specific controller and device identification, description and location information.

5. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Paragraph 3.15A.9.

6. Copy of inspection certificates provided by the local code authorities.

7. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.

8. Training materials as required by Paragraph 3.16.

9. Contact information. Names, addresses, and 24-hour telephone numbers of contractors installing equipment, and the control systems and service representatives of each.

C. Format of Completion Documents

1. Provide the type and quantity of media listed in table below.

2. Project database, programming source files, and all other files required to modify, maintain, or enhance the installed system shall be provided in their source format and compiled format (where applicable).

3. Where electronic copies are specified, comply with the following:
   a. Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf), and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.
   b. For submittals, provide separate file for each type of equipment.
   c. Control sequences shall be in MS Word.

	Document	Paper (binder or bound)	Electronic	
			Loaded onto Flash Drive	Loaded onto CSS
1.	O&M Manual	2	1	1
2.	Project database including all source files	–	1	1
3.	Project Record Drawings	2	1	1
4.	Control sequences	1	1	1
5.	Commissioning Reports	2	1	1
6.	Inspection Certificates	1	1	1
7.	Warranty documents	1	1	1
8.	Training materials	1 per trainee	1	1
9.	Contact information	1	1	–

D. Permanent On-site Documentation

1. In each panel, provide the following stored in clear plastic sleeve taped to the back of the panel door:
   a. 8.5x11 printout of as-built points list
   b. 21 inch x 15 inch or 17 inch x 11 inch set of as-built shop drawings for devices in panel

1.11 BAS DESIGN

A. System Architecture

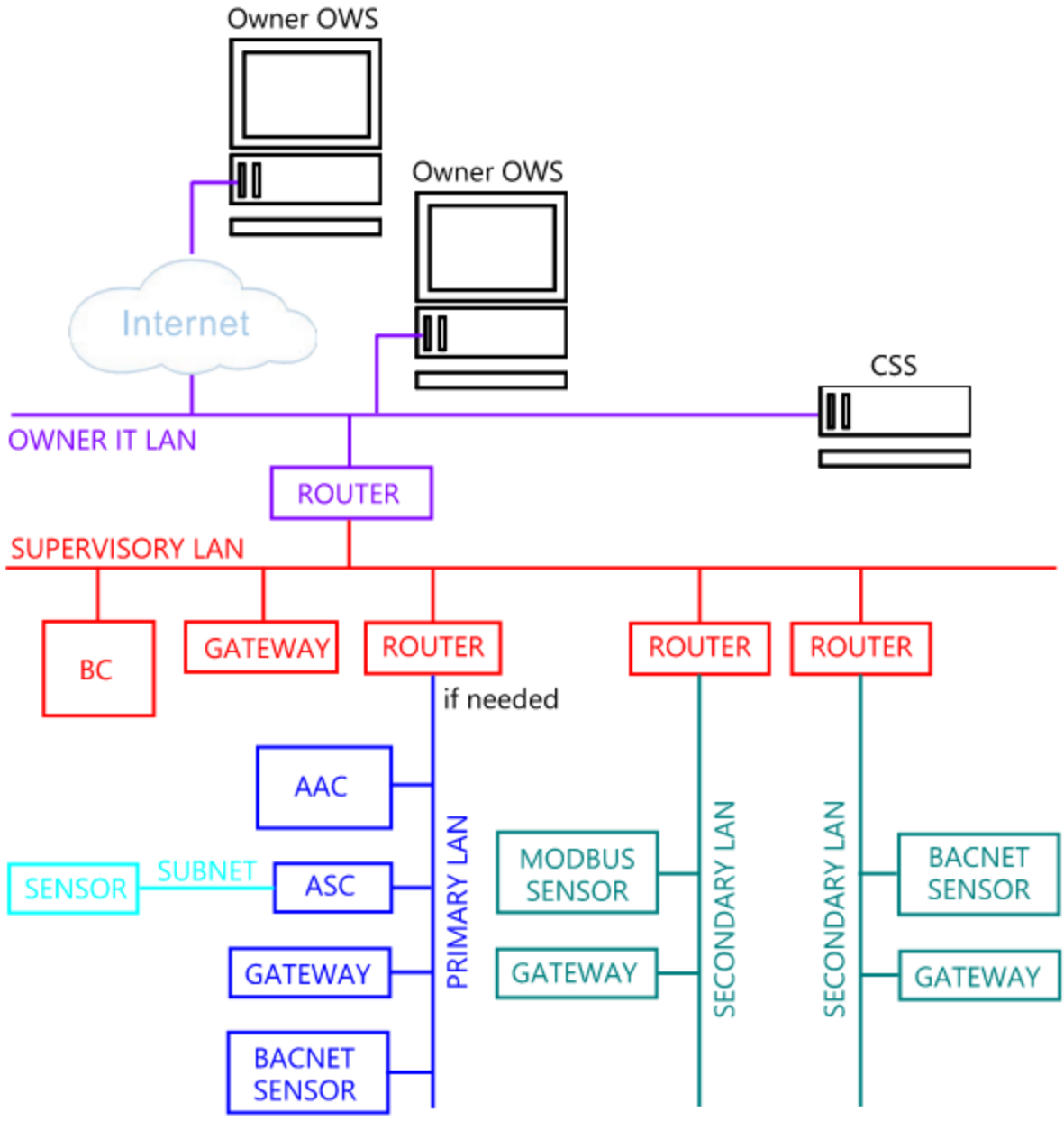
1. General
   a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified in this Section. Include all items not

specifically itemized in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Section.

b. The system shall be configured as a distributed processing network(s) capable of expansion as specified herein.
c. The existing Campus BAS consists of a control system server interconnected by a high speed College IT LAN to each campus building and facility. This project includes integrating building level BCs and other control devices into the campus system.
   1) Within the building, the BAS shall be standalone and not rely on any 3rd party networks, such as the College IT LAN, except as specifically allowed herein.
   2) To communicate with the central CSS (and internet via VPN), the building Supervisory LAN shall connect via router, provided under this Section, to the College IT LAN. Arrange with College IT administrators for final connection and IP addresses.
d. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ANSI/ASHRAE Standard 135.
e. Power-line carrier systems are not acceptable for BAS communications.

2. BAS Network Architecture
   a. College IT LAN. Ethernet-based, 100 or 1000 Mbps BACnet/IP network. Reuse existing connections to existing network controllers. No additional drops will be provided by the College.
   b. Supervisory LAN: The LAN shall be an Ethernet-based, 100 or 1000 Mbps network interconnecting the server and OWS(s) to BCs and certain gateways as specified herein. LAN shall be IEEE 802.3 Ethernet with switches and routers that support 100 Mbps minimum throughput. This network shall be BACnet/IP as defined in the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.
   c. Primary LAN: High-speed, peer-to-peer communicating LAN used to connect AACs, ASCs, and certain gateways and sensors where specified herein. Acceptable technologies include and are limited to:
      1) Ethernet (IEEE802.3) per the Supervisory LAN
      2) ARCnet (IEEE802.4) for Alternate Bid Only; see Paragraph 1.2H.1.
   d. Secondary LAN: Network used only to connect certain gateways and sensors where specified herein. It shall <u>not</u> be used to interconnect BCs, AACs, and ASCs. Network speed versus the number of devices on the LAN shall be dictated by the response time and trending requirements. Acceptable technologies include but are not limited to:
      1) BACnet over Master Slave/ Token Passing (MS/TP)
      2) Modbus over RS-485 or IP
   e. Subnets: Networks used to connect sensors and thermostats to AACs and ASCs. This network may as above for Secondary LANs or may be proprietary the manufacturer.

3. The figure below shows a schematic of the desired network architecture. Note that the CSS may be remote at the Brentwood campus as indicated in Paragraph 1.2H.2.



4. Operator Interfaces and Servers
   a. The Control Systems Server (CSS) is existing. See Paragraph 1.3C.6 for temporary CSS requirements.
   b. OWSs or POTs are either existing or will be provided by the College.
   c. Remote monitoring and control shall be through use of a web browser through the College IT LAN and via the internet through the College IT LAN.

5. Controllers. The BCs, AACs, and ASCs shall monitor, control, and provide the field interface for all points specified.

6. Gateways and Routers
   a. See Paragraph 2.4C for a list of gateways and routers.

b. Where gateways are used, critical points shall be hardwired from the BAS to the controlled device, rather than using the gateway, to avoid problems with gateway failures, currently a common problem. Critical points are those that are essential for proper operation and are listed in points list as separate points. Where listed, these points shall be hardwired even when available through gateway.

B. System Performance

1. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. This includes when system is collecting trend data for commissioning and for long term monitoring. (See Paragraph 3.15E.) In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Reconfigure LAN as necessary to accomplish these performance requirements. This does not apply to gateways and their interaction with non-BAS-vendor equipment.
   a. Object Command: The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.
   b. Object Scan: All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.
   c. Graphics Scan: The maximum time between an operator's selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.
   d. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast (where so programmed) shall not exceed 10 seconds for a Level 1 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.
   e. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
   f. Control Loop Performance: Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

2. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

Measured Variable	**Reported Accuracy**
Space drybulb temperature	±1ºF
Ducted Air drybulb temperature	±0.5ºF
Mixed Air drybulb temperature	±1ºF
Outside Air drybulb temperature	±0.5ºF

Measured Variable	Reported Accuracy
Chilled and Condenser Water Temperature	±0.2ºF
Hot Water Temperature	±0.5ºF
Water Flow	±1% of reading
Airflow (terminal)	±10% of reading
Airflow (measuring stations)	±5% of reading
Air Pressure (ducts)	±0.05 inches
Air Pressure (space)	±0.01 inches
Water Pressure	±2% of reading
Electrical power	1% of reading
Carbon Dioxide (CO_2)	±75 ppm

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed software and documentation shall become the property of the College. These include, but are not limited to:

1. Project graphic images

2. Record drawings

3. Project database

4. Project-specific application programming code

5. All documentation

1.13 WARRANTY

A. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the College and if all completion requirements per Paragraph 1.10B have been fulfilled, the College shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

B. Guarantee all materials, equipment, apparatus and workmanship (including programming) to be free of defective materials and faulty workmanship for the following periods from date of acceptance:

1. BCs, AACs, and ASCs: two years

2. Valve and damper actuators: five years

3. All else: one year

C. Provide new materials, equipment, apparatus and labor to replace that determined by College to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the College. Contractor shall

respond to the College's request for warranty service within 24 hours during normal business hours.

E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies shall be provided at no cost to the College during the warranty period.

F. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall be provided at no additional cost to the College during this period.

1.14 WARRANTY MAINTENANCE

A. The College reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the College, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

B. At no cost to the College, provide maintenance services for software and hardware components during the warranty period as specified below:

1. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the College to the Contractor.
   a. Response by telephone or via internet connection to the BAS to any request for service shall be provided within two hours of the College's initial request for service.
   b. In the event that the malfunction, failure, or defect is not corrected, at least one technician, trained in the system to be serviced, shall be dispatched to the College's site within eight hours of the College's initial request for such services.

2. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following notification by the College to the Contractor.
   a. Response by telephone to any request for service shall be provided within eight working hours (contractor specified 40 hr. per week normal working period) of the College's initial request for service.
   b. In the event that the malfunction, failure, or defect is not, at least one technician, trained in the system to be serviced, shall be dispatched to the College's site within three working days of the College's initial request for such services, as specified.

3. College's Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for College to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One

of the three paged/texted technicians shall respond to every call within 15 minutes.

4. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.

5. Documentation: Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.

PART 2 PRODUCTS

2.1 PRIMARY BAS MANUFACTURER

A. Automated Logic Corp.

B. No Equal

2.2 GENERAL

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way.

B. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

C. All controllers, associated hardware (repeaters, routers, etc.), sensors, and control devices shall be fully operational and maintain specified accuracy at the anticipated ambient conditions of the installed location as follows:

1. Outdoors or in harsh ambient conditions: -20°C to 55°C (-4°F to 130°F), 10% RH to 90% RH noncondensing.

2. Conditioned spaces or mechanical rooms: 0°C to 40°C (32°F to 104°F), 10% RH to 80% RH noncondensing.

2.3 CONTROLLERS

A. Building Controller (BC)

1. ALC OptiFlex line

B. Advanced Application Controller (AAC)

1. ALC OptiFlex line

2. ALC ME or SE-series for Alternate Bid Only; see Paragraph 1.2H.1.

C. Application Specific Controller (ASC)

1. ALC OptiFlex line

2. ALC ZN-series for Alternate Bid Only; see Paragraph 1.2H.1.

2.4 COMMUNICATION DEVICES

A. Supervisory LAN Protocol Translators

1. ALC Optiflex line

B. BACnet Gateways & Protocol Translators

1. Gateways shall be provided to link non-BACnet control products to the BACnet inter-network. All of the functionality described in this Paragraph is to be provided by using the BACnet capabilities. Each Gateway shall have the ability to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.

2. Each Gateway shall provide values for all points on the non-BACnet side of the Gateway to BACnet devices as if the values were originating from BACnet objects. The Gateway shall also provide a way for BACnet devices to modify (write) all points specified by the Points List using standard BACnet services.

C. Gateway and Protocol Translators

Equipment/System	Interface			
	Type	Specified Under Division:	Location	Connect to this Network:
Variable Speed Drives (Alternate Bid only – See Paragraph 1.2H.3.)	BACnet/MSTP	(E)	Each VFD	Secondary
Chiller (Existing)	BACnet/IP or BACnet/MSTP per existing (verify)	(E)	Chiller Room	Supervisory or Secondary per existing
Power Monitoring (New)	Modbus RS-485	(E)	Electrical Room 138 (formerly 137)	Secondary
Refrigerant Monitor (New)	Modbus RS-485	(E)	Chiller Room	Secondary

2.5 BAS INTERFACE HARDWARE

A. Not required (existing or virtual server provided by College as Alternate per Paragraph 1.2H.2.)

2.6 AIR TUBING

A. Seamless copper tubing, Type L-ACR, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder.

B. Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

2.7 ELECTRIC WIRING AND DEVICES

A. Communication Wiring

1. Provide all communication wiring between Building Controllers, Protocol Translators, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).

2. Ethernet LAN: Use Fiber or Category 5e or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.

3. ARCnet and RS-485 LAN: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30 volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

B. Analog Signal Wiring

1. Input and output signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, current or voltage analog outputs, etc. shall be twisted pair, 100% shielded if recommended or required by controller manufacturer, with PVC cover. Gauge shall be as recommended by controller manufacturer.

2.8 NEW CONTROL CABINETS

A. Existing control cabinets may be reused. This section applies to new cabinets.

B. All control cabinets shall be fully enclosed with hinged door.

1. For panels in mechanical rooms and other spaces that are secure and accessible only to BAS/MEP operators, provide quarter-turn slotted latch.

2. For panels located in electrical rooms, IDF rooms, and other spaces that may be accessible by persons other than BAS/MEP operators, provide key-lock latch. A single key shall be common to all panels within each building. Provide 3 keys.

C. Construction

1. Indoor:
   a. Mechanical or electrical rooms etc.: NEMA 1
   b. Air plenums: NEMA 12

2. Outdoor: NEMA 4

D. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified

per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

E. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

F. For new and existing panels, provide with

1. Framed, plastic-encased point list for all points in cabinet.

2. Nameplates for all devices on face.

2.9 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. The listing of several sensors or devices in this section does not imply that any may be used. Refer to points list in Paragraph 2.13 Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Contractor choose among listed products.

B. Existing valve bodies may be reused at Contractor’s option.

C. Control Valves

1. Manufacturers
   a. Belimo
   b. No equal

2. Modulating Characterized Ball Valves
   a. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (2-way valves) or 400 psi rating (3-way valves). The stem packing shall consist of 2 lubricated O-rings designed for modulating service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   f. Ball: stainless steel
   g. Stem: stainless steel
   h. Characterizing disk held securely by a keyed ring providing equal percentage characteristic

3. Minimum valve assembly pressure ratings
   a. Chilled water: 125 psi at 60ºF
   b. Hot water: 125 psi at 200ºF
   c. Condenser water: 125 psi at 100ºF

4. Valve Selection
   a. Valve type
      1) Modulating 2-way valves: characterized ball type
   b. Valve Characteristic
      1) 2-way valves: equal percentage or modified equal percentage.
   c. Valve Sizing
      1) Modulating Water: Size valve to achieve the following full-open pressure drop
         a) Minimum pressure drop: equal to half the pressure drop of coil or exchanger.
         b) Maximum pressure drop
            1. Hot water at coils: 2 psi
            2. Chilled water at coils: 5 psi
         c) Flow coefficient (C_v) shall not be less than 1.0 (to avoid clogging) unless protected by strainer. Verify in field that a strainer has been provided.
         d) Valve size shall match as close as possible the pipe size where C_v is available in that size.

D. Control Dampers

1. Reuse existing.

E. Actuators

1. Manufacturers
   a. Belimo
   b. No equal

2. Warranty: Valve and damper actuators shall carry a manufacturer's 5-year warranty.

3. Electric Actuators
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
   d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.
   e. Actuator shall have microprocessor-based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.

g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.
h. Modulating Actuators. Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.
i. Where indicated on Drawings or Points List, actuators shall include
   1) 2 to 10 VDC position feedback signal
   2) Limit (end) position switches
j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.
k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
l. Actuators shall be provided with a conduit fitting an a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
m. Where fail-open or fail-closed (fail-safe) position is required by Paragraph 2.9E.4, an internal mechanical, spring return mechanism shall be built into the actuator housing. Electrical capacitor type fail-safe are also acceptable. All fail-safe actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.
o. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.
p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.
q. Actuators shall provide clear visual indication of damper/valve position.

4. Normal and Fail-Safe Position
   a. Except as specified otherwise herein, the normal position (that with zero control signal) and the fail-safe position (that with no power to the actuator) of control devices and actuators shall be as indicated in table below. “Last” means last position. Actuators with a fail-safe position other than “Last” must have spring or electronic fail-safe capability.

Device	**Normal Position**	**Fail-Safe Position**
Outside air damper	CLOSED	CLOSED
Return air damper	OPEN	OPEN
Exhaust/relief air damper	CLOSED	CLOSED
AHU heating coil valves	OPEN	LAST
AHU cooling coil valves	CLOSED	LAST

Device	Normal Position	Fail-Safe Position
Hot water reheat coil valves	CLOSED	LAST
Minimum flow bypass valves	OPEN	LAST
VAV box dampers	OPEN	LAST
Laboratory hood exhaust air valves	OPEN	LAST
Laboratory supply air valves	OPEN	LAST
Laboratory general exhaust valves	CLOSED	LAST
Laboratory fume hood exhaust minimum airflow damper	CLOSED	CLOSED

5. Valve Actuator Selection
   a. Modulating actuators for valves shall have minimum rangeability of 50 to 1.
   b. Tight closing against 125% of system pump shut-off head.
   c. Modulating duty against 90% of system pump shut-off head.

6. Damper Actuator Selection
   a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
   b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer's recommendations and the following:
      1) Torque shall be a minimum 5 inch-pound per square foot for opposed blade dampers and 7 inch-pound per square foot for parallel blade dampers.
      2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating.

F. General Field Devices

1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.

2. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

3. Field devices specified herein are generally two-wire type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with two-wire type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, provide a transmitter and necessary regulated DC power supply, as required.

4. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

5. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device and as required by Paragraph 1.11B.2.

G. Temperature Sensors (TS)

1. General
   a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
   b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3ºF (0.16 °C) (unless noted otherwise herein).
   c. Sensors shall drift no more than 0.3ºF and shall not require calibration over a five-year period.
   d. Manufacturers
      1) Mamac
      2) Kele Associates
      3) Building Automation Products Inc.
      4) Automated Logic Corp.
      5) Or equal

2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.
   a. TS-1A: Single point (use where not specifically called out to be averaging in points list). Sensor probe shall be 304 stainless steel.
   b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum. Sensor probe shall be bendable aluminum.

3. Water Temperature Sensors
   a. TS-2A: Well mounted immersion sensor, ¼" stainless steel probe, double encapsulated sensor, with enclosure suitable for location.
   b. All piping immersion sensors shall be in one-piece machined brass or stainless steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.

4. Room Sensors
   a. Thermostat tags refer to the following:

Type:	Tag
Model	ZS2 Plus
Temperature only	TS-3C
With CO_2	TS-3CC

      1) Display
         a) LCD display of all sensors, temperature setpoint adjustment buttons, and schedule override button

2) CO2 Sensor
   a) 400 to 1250 PPM/ ±30PPM or 3% of reading, whichever is greater.
   b) The sensor shall include automatic background calibration (ABC) logic to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the College within 5 years of purchase date.
   c) Meet Title 24 requirements including calibration interval
   d) Provide where CO_2 sensor called for in the VAV box schedule herein.
3) For room sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration.

5. TS-4: Outdoor Air Sensor
   a. Thermistor with sun shield, utility box, and watertight gasket to prevent water seepage.

6. Temperature Transmitters: Where required by the Controller or to meet specified end-to-end accuracy requirements, sensors as specified above shall be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

H. Pressure Transmitters (PT)

1. PT-1: Water, General Purpose
   a. Fast-response stainless steel sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.5% full scale, includes non-linearity, repeatability, and hysteresis
   d. Long Term Stability 0.5% FS per year
   e. Pressure Limits
      1) Rated pressure: see points list
      2) Proof pressure = 3x rated pressure
      3) Burst pressure = 5x rated pressure
   f. Manufacturers
      1) Setra 209
      2) Kele & Associates P51 Series
      3) Or equal

I. Differential Pressure Transmitters (DPT)

1. DPT-1: Water, General Purpose
   a. Fast-response capacitance sensor
   b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
   c. Accuracy
      1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
      2) Non-Linearity, BFSL ±0.22% FS.
      3) Hysteresis 0.10% FS.
      4) Non-Repeatability 0.05% FS.

d. Long Term Stability 0.5% FS per year
e. Only 316 stainless steel in contact with fluid
f. Pressure Limits
    1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.
    2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.
g. Include brass 5-valve assembly for single sensor devices. See Paragraph 3.11E.7.
h. Manufacturers
    1) Setra 209 or 230
    2) Modus W30
    3) Or equal

2. DPT-2: Not used

3. DPT-3: Air, Duct Pressure:
    a. General: Loop powered two-wire differential capacitance cell-type transmitter.
    b. Output: two wire 4-20 mA output with zero adjustment.
    c. Overall Accuracy: ±1% of range (not of maximum range/scale)
    d. Switch selectable range:
        1) ≥ 0.5 inches water column
        2) ≤10 inches water column
        3) Select range as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.
    e. Housing: Polymer housing suitable for surface mounting.
    f. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal, with connecting tubing.
    g. DPT-3A: Include LCD display of reading.
    h. DPT-3B: Same as DPT-3 except with stainless steel pitot-type static pressure sensing tips similar to Dwyer model A-301-SS, or equal.
    i. Manufacturers.
        1) Setra
        2) Modus
        3) Dwyer
        4) Or equal

4. DPT-4: Air, Low Differential Pressure
    a. General: Loop powered, two-wire differential capacitance cell type transmitter.
    b. Output: Two-wire 4-20 mA output with zero adjustment.
    c. Overall Accuracy
        1) General: ±1% FS
        2) Underfloor: ±0.5% FS
        3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS
    d. Range
        1) Fixed (non-switch selectable)
        2) Minimum Range: 0, -0.1, -0.25, -0.5, or -1.0 inches water column
        3) Maximum Range: +0.1, 0.25, 0.5, or 1.0 inches water column

4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.
e. Housing: Polymer housing suitable for surface mounting
f. Static Sensing Element
1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal
2) Space sensor:
a) Wall plate: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465 or equal
b) Ceiling or wall probe: BAPI ZPS-ACC06, Dwyer A-419A, Veris AA05 or equal
3) Filter or duct pressure sensor: Dwyer A-301 or equal
4) Plenum pressure sensor: Dwyer A-421 or equal
g. DPT-4A: Include LCD display of reading
h. Manufacturers
1) Setra 267
2) Modus
3) Air Monitor
4) Paragon
5) Or equal

5. DPT-5: VAV Velocity Pressure
a. General: Loop powered two-wire differential capacitance cell type transmitter.
b. Output: Two-wire, 4-20 mA output with zero adjustment.
c. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004 inches differential pressure or lower, shall be capable of sensing 0.002 inches differential pressure or lower, and shall have a ±0.001 inches or lower resolution across the entire scale.
d. Calibration software shall use a minimum of two field measured points, minimum and maximum airflow, with curve fitting airflow interpolation in between.
e. Range: 0 to 1 in.w.c.
f. Housing: Polymer housing suitable for surface mounting.
g. Manufacturer
1) Automated Logic
2) No equal

J. Differential Pressure Switches (DPS)

1. Reuse existing

K. Current Switches (CS-1)

1. Clamp-on or solid-core

2. Range: as required by application

3. Trip Point: Automatic or adjustable
a. Exception: Fixed setpoint (Veris H-600 or equal) may be used on direct drive constant speed fans that do not have backdraft or motorized shutoff dampers.

4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage

5. Lower Frequency Limit: 6 Hz

6. Trip Indication: LED

7. Approvals: UL, CSA

8. May be combined with relay for start/stop

9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal

10. Manufacturers
    a. Veris Industries H-608/708/808/908
    b. Senva C-2320L
    c. RE Technologies SCS1150A-LED
    d. Or equal

L. Current Transformers (CT-1)

1. Clamp-On Design Current Transformer (for Motor Current Sensing)

2. Range: 1-10 amps minimum, 20-200 amps maximum

3. Trip Point: Adjustable

4. Output: 0-5 Vdc or 0-10 Vdc,

5. Accuracy: ±0.2% from 20 to 100 Hz.

6. Amperage range sizing and switch settings in accordance with the following and per manufacturer's instructions:

Motor HP	120V	277V	480V
≤1/2	0-10A	0-10A	−
3/4 – 1.5	−	0-10A	0-10A
2 – 5	−	−	0-10A
7.5 − 10	−	−	0-20A
15 − 20	−	−	0-30A
25 − 30	−	−	0-40A

7. Manufacturers
    a. Veris Hx22 series
    b. Kele SC100
    c. Or equal

M. Flow Meter (FM)

1. FM-1: Magnetic Flow Tube Flow Meters (Alternate Bid only)
    a. General Requirements

1) Sensor shall be a magnetic flow meter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
2) Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
3) Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.
    a) On applications where the output is wired to a BTU meter but flow is required also as a direct input to the DDC system, e.g. for minimum flow control loop, provide a secondary analog output for the DDC system.
4) Flow Tube
    a) ANSI class 150 psig steel
    b) ANSI flanges
    c) Lined with
        1. Heating hot water, glycol: PTFE, PFA, or ETFE liner rated for ≤-4°F to ≥212ºF fluid temperature
        2. Chilled, condenser, domestic hot and cold water: Polypropylene, Ebonite, PTFE, PFA, or ETFE liner rated for ≤32°F to ≥140ºF fluid temperature
5) Electrode and grounding material
    a) 316L Stainless steel or Hastelloy C
    b) Electrodes shall be fused to ceramic liner and not require O-rings.
6) Electrical Enclosure: NEMA 4
7) Approvals
    a) UL or CSA
    b) NSF Drinking Water approval for domestic water applications
8) Performance
    a) Accuracy shall be:
        1. ±0.4% of reading from 3.3 to 33 ft/s
        2. ±0.75% of reading from 1.3 to 3.3 ft/s
        3. ±0.0075 ft/s at flow rates less than 1 ft/s
    b) Stability: 0.1% of rate over six months.
    c) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
    d) Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.

b. Manufacturers
    1) Onicon F-3100 series
    2) Siemens/Danfoss Magflo 3100
    3) Krohne Optiflux 4000
    4) Sparling TigermagEP FM656
    5) Or equal

2. FM-2: Magnetic Insertion Type Flow Meters
   a. Magnetic Faraday point velocity measuring device.
   b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
   c. 4-20 mA transmitter proportional to flow or velocity.
   d. Accuracy: ± 1% of reading from 0.25 to 20 fps
   e. Flow range: 0.25 to 20 fps
   f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute of Standards and Technology (NIST).
   g. Manufacturers:
      1) Onicon FSM-3
      2) Or equal

3. FM-3B: Mass Flow Meter (Alternate Bid only)
   a. Thermal mass flow gas meter designed for measurement of widely varying flow rates of low pressure natural gas
   b. Precision platinum resistance temperature detectors protected by a platinum-iridium sheath mounted in 316 SS probe
   c. Operating temperature range: -40°F to +140°F
   d. 4-20mA, 0-5 Vdc, or 0-10 Vdc output proportional to mass flow
   e. NIST-traceable factory calibration
   f. ±1% FS accuracy
   g. Rangeability at ±1% accuracy: Minimum 40 to 1
   h. Glass enclosed 8 digit totalizer, re-zeroed with on-board device
   i. Manufacturer
      1) Sierra Instruments 620S or 620S BT
      2) Or equal

4. FM-4: Not used

5. FM-5: Not Used

6. FM-6: Domestic and makeup water meters (Alternate Bid only)
   a. 2 inches and smaller: Multi-jet water meter
      1) Multi-jet velocity type meter
      2) Magnetic drive – no gearing exposed to water
      3) 125 psi cast bronze body with integral strainer
      4) Meet all requirements of AWWA C-708 Multi-Jet Meter
      5) Accuracy: ±1.5% of reading
      6) Hall affect low voltage pulse output, with configurable volume per pulse set to 1 gallon per pulse or smallest value the controller will accept
      7) Odometer-type gallons totalizer dial face with cover
      8) Designed for vertical or horizontal piping
      9) For potable water: NSF-61 certified and in compliance with California Proposition 65
      10) Manufacturers:
         a) SeaMetrics MJE or MJHE
         b) Elster Amco M700
         c) Master Meter

d) Equal

b. 2.5 inches and larger: Compound-type water meter
   1) Shall consist of a combination of a turbine-type, mainline meter for measuring high rates of flow and a bypass meter of an appropriate size for measuring low rates of flow. The compound meter shall have an automatic valve mechanism for diverting low rates of flow through the bypass meter.
   2) Comply with ANSI and AWWA C702 standards.
   3) Comply with NSF/ANSI Standard 61, ANNEX G.
   4) Maximum operating pressure of 150 psi and maximum operating temperature of 120°F continuous (220°F peak).
   5) Low voltage pulse output, with configurable volume per pulse set to 1 gallon per pulse or smallest value the controller will accept
   6) Odometer-type gallons totalizer dial face with cover
   7) Manufacturers:
      a) Badger Recordall Series Meter
      b) Neptune
      c) Or equal
   8) Or equal

N. Airflow Measuring Stations (AFMS)

1. General. AFMS provided under this Section shall be licensed to bear the AMCA Certified Rating Seal for Airflow Measuring Stations. Ratings shall be based on tests and procedures performed in accordance with AMCA Publication 611 and comply with requirements of the AMCA Certified Ratings Program.

2. AFMS-1. Not used.

3. AFMS-2. Not used.

4. AFMS-3. Not used.

5. AFMS-4
   a. Differential pressure type with uniframe DP sensor
      1) Provide quantity of DP sensors per manufacturer's recommendations
   b. Station mounted with expanded metal screen
   c. Analog outputs for "standard" airflow (0.075 lb_{da}/ft3 density) and temperature
   d. Manufacturers
      1) Air Monitor OAM-II mounted on outside of outdoor air louver
      2) No known equal

O. Electric Control Components

1. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
   a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
      1) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
      2) Coil sealed volt-amperes (VA) not greater than 4 VA.

3) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
4) Pilot light indication of power-to-coil and coil retainer clips.

b. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.
c. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

2. Control Transformers and Power Supplies
   a. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Mount in minimum NEMA-1 enclosure.
   b. Transformer shall be proper size for application. Limit connected loads to 80% of rated capacity.
   c. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection, and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
   d. Separate power transformer shall be used for controllers and for actuators and other end devices that use half wave rectification.
   e. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
   f. Line voltage units shall be UL Recognized and CSA Approved.

2.10 LABORATORY AIR VALVES

A. Materials

1. Airflow control valve shall be constructed as follows:
   a. Supply and General Exhaust
      1) Body: 20 gauge galvanized or 16 gauge aluminum with continuous welded seam
      2) Damper: 16 gauge galvanized or aluminum
      3) Shafts, support brackets, and springs (where used): 316 stainless steel
      4) Bearings: Teflon, polyester, or polyphenylene sulfide composite
   b. Fume Hood Exhaust
      1) Body: 20 gauge 304 stainless steel or galvanized steel with baked phenolic coating with continuous welded seam
      2) Damper: 16 gauge stainless steel or galvanized steel with baked phenolic coating
      3) Shafts, support brackets, and springs (where used): 316 stainless steel
      4) Bearings: Teflon, polyester, or polyphenylene sulfide composite
      5) No aluminum or galvanized steel exposed to airstream

2. Include draw bands with clamps on each duct connection.

3. Include factory thermal insulation kit for all supply air valves, flexible closed-cell elastomeric type, vapor sealed, thickness per code.

4. For general exhaust, leakage through valve assembly when fully closed shall not exceed 10 cfm at 3 in.w.c. Provide blade seals ("-S" version) as required to meet this limit.

B. Variable Volume Airflow Control Valve

1. Minimum turndown:
   a. Fume hood air valves: 5 to 1
   b. Others: 8 to 1
   c. Shut-off feature: any air valves scheduled to have a 0 cfm minimum shall have full shut-off capability when sent a 0 cfm setpoint.

2. Closed Loop Control
   a. Control damper with fast-acting electric actuator
      1) Fail position. Loss of control power shall cause valves to fail in the last position prior to power loss.
   b. Airflow indicator/sensor accurate to within ±5% of reading over entire turndown range with an analog output (0-10 Vdc) signal. Velocity sensors shall not be affected by dust, temperature, pressure, or humidity. The sensors shall be passive in nature, with no active parts within the air stream. Pitot, thermal anemometer, and other devices mounted in airstream are not acceptable on fume hood air valves. Vortex shedding type is acceptable.
      1) Factory calibrated.
   c. Robust closed loop controller using airflow sensor to control the damper to maintain an airflow setpoint provided by an external analog input (0-10 Vdc) signal with the range, speed, and accuracy specified herein.
   d. Analog output (0-10 Vdc) signal to the damper actuator or a feedback signal from the actuator indicating damper position.
   e. Dry contact input for presence sensor configured to drop maximum hood exhaust setpoint to 60% of design maximum value.

3. Sash Position Sensor
   a. For air valves controlling fume hood exhaust
   b. Output: 0-10000 Ohms proportional to sash position or as required by air valve controller
   c. Linearity: 0.1%
   d. Accuracy: 3%
   e. Ambient conditions: 60°F to 100°F, 0% to 95% RH
   f. Range: as required to match hood
   g. Vertical, horizontal, or combination to match hood
   h. Manufacturer: Same as air valve controller

4. Fume Hood Monitor
   a. Designed to integrate with air valve controller
   b. LCD with velocity indication
   c. Visual and audible low and high velocity alarms with message display and mute button

d. Button to activate and deactivate emergency purge that causes air valve to operate at full airflow regardless of sash position
e. Manufacturer: Same as air valve controller

C. Manufacturer

1. AccuValve AVC-6000

2. No equal

2.11 CALIBRATION & TESTING INSTRUMENTATION

A. Provide instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (for example if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

2.12 SOFTWARE

A. General

1. Upgrade CSS software to the latest version of ALC WebCTRL.

B. Licensing

1. Include licensing and hardware keys for all software packages at all workstations (OWSs and POTs) and servers.

2. Within the limitations of the server, provide licenses for any number of users to have web access to the CSS at any given time.

3. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the College.

4. All operator software, including that for programming and configuration, shall be available on all workstations. Hardware and software keys to provide all rights shall be installed on all workstations.

C. Graphical User Interface Software

1. Graphics
a. The GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics and active setpoint graphic controls shall be used to enhance usability.

b. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.
c. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.
d. Links
    1) Graphics shall include hyperlinks which when selected (clicked on with mouse button) launch applications, initiate other graphics, etc.
    2) Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic. See additional discussion in Paragraph 3.12E.
    3) Information Links
        a) On each MEP system and subsystem graphic, provide links to display in a new window the information listed below.
            1. English-language as-built control sequence associated with the system. See Paragraph 1.10B.
            2. O&M and submittal information for the devices on the graphic. See Paragraph 1.10B.
        b) The display shall identify the target of the link by file name/address.
        c) Information shall be displayed in electronic format that is text searchable.
        d) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software.
e. Point Override Feature
    1) Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.
    2) When the point is selected to be commanded
        a) Dialog box opens to allow user to override the point (Operator Mode) or release the point (Automatic Mode). Operator Mode will override automatic control of the point from normal control programs.
        b) Dialog box shall have buttons (for digital points) or a text box or slide bar (for analog points) to allow user to set the point's value when in operator mode. These are grayed out when in automatic mode.
        c) When dialog box is closed, mode and value are sent to controller.
        d) Graphic is updated upon next upload scan of the actual point value.
    3) A list of points that are currently in an operator mode shall be available through menu selection.
f. Point override status (if a digital point is overridden by the supervised manual override per Paragraph 2.3A or if a point is in operator mode per Paragraph 2.12C.1.e) shall be clearly displayed on graphics for each point, such as by changing color or flag.
g. The color of symbols representing equipment shall be able to change color or become animated based on status of binary point to graphically represent on/off status.

2. Alarms
    a. ALC WebCTRL Enterprise Integration advanced alarm package configured as indicated below.

3. Trends

a. ALC WebCTRL Enterprise Integration trend package configured as indicated below.
b. Trend Data Storage
   1) The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS using SQL queries.
   2) Data shall be stored in an SQL compliant database format and shall be available through the College's intranet or internet (with appropriate security clearance) without having to disable BAS access to the database.
   3) The database shall not be inherently limited in size, e.g. due to software limitations or lack of a correct license. Database size shall be limited only by the size of the provided storage media (hard drive size).

4. Security Access
   a. Standard ALC WebCTRL security package

5. Report Software
   a. ALC WebCTRL Enterprise Integration advanced reporting package.
   b. Standard reports. Prepare the following standard reports, accessible automatically without requiring definition by user.
      1) Tenant or department after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC services.
      2) Monthly and annual energy usage and cost. See Utility cost calculation in Paragraph 3.12.
      3) Alarm events and status.
      4) Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.

D. Control Programming Software

1. Standard ALC WebCTRL Eikon programming.

E. Miscellaneous Software

1. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide relevant data for the application or object that help is being called from.

2. Provide software for viewing (but not editing) electronic versions of as-built shop drawings of
   a. Mechanical, electrical, and plumbing systems in Adobe pdf format
   b. BAS drawings in Adobe pdf format

2.13 CONTROL POINTS

A. Table Column Definitions

1. Point description

2. Type (number in point schedule after each type refers to tag on schematics)
   a. AO: analog output
   b. AI: analog input
   c. DO: digital or binary output
   d. DI: digital or binary input

3. Device description
   a. See Paragraph 2.9 for device definition.

4. Trend Logging
   a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes.
   b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.
   c. Trend Basis
      1) Where range of engineering units is listed, trend on a change of value (COV) basis (in other words record time stamp and value when point value changes by engineering unit listed).
      2) Where time interval is listed, trend on a time basis (in other words record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day so data can be compared in text format.

5. Calibration
   a. F = factory calibration only is required (no field calibration)
   b. HH = field calibrate with handheld device. See Paragraph 3.15B.6.a.2)

B. Note that points lists below are for each system of like kind. Refer to drawings for quantity of each.

C. Points mapped through gateways and network interfaces. Note that points listed herein are intended to indicate the level of effort required for point mapping for bid purposes; the points lists are not exclusive and exhaustive. The exact point names and types may vary since the points available vary by equipment manufacturer and model. A final list of available points must be obtained from the manufacturer during the shop drawing development phase. If the available points differ from the points lists herein, the desired points to be mapped shall be confirmed by the Engineer prior to issuing Submittal Package 2. Unless the quantity of points is significantly different from those shown herein, the changes shall be made at no additional costs to the College.

1. Variable speed drives (Alternate Bid only – See Paragraph 1.2H.3.)

Description	Type	Device	Trend Logging		Calibra-tion
			Comm-issioning	Contin-uous	
Fault reset	DO	Through network	COV	COV	–
On/off status	DI	Through network	COV	COV	–
Fault (critical alarm)	DI	Through network	COV	COV	–
Minor alarm	DI	Through network	COV	COV	–
Fault text	AI	Through network (convert code to plain English text)	COV	COV	–
Alarm text	AI	Through network (convert code to plain English text)	COV	COV	–
Keypad in hand/auto	DI	Through network	COV	COV	–
Minimum frequency setpoint	AO	Through network	±5%	±5%	–
Maximum frequency setpoint	AO	Through network	±5%	±5%	–
Acceleration rate	AO	Through network	±5%	±5%	–
Deceleration rate	AO	Through network	±5%	±5%	–
Actual frequency	AI	Through network	1 min	15 min	–
DC bus voltage	AI	Through network	±10%	±10%	F
AC output voltage	AI	Through network	±10%	±10%	F
Current	AI	Through network	15 min	60 min	F
VFD temperature	AI	Through network	60 min	60 min	F
Power, kW	AI	Through network	1 min	15 min	F
Energy, MWh	AI	Through network	15 min	60 min	–

2. Chillers:
   a. See existing interface. Map across all points currently mapped to Andover. See Andover “dump” files included in bid package. That includes on/off – all chiller control shall be through the existing BACnet interface.

3. Electrical Power Monitor
   a. New connection to existing GE EPM 5100

Description	Type	Device	Trend Logging		Calibra-tion
			Comm-issioning	Contin-uous	
kW	AI	Through network	15 min	15 min	–
Volts (each phase)	AI	Through network	±10%	±10%	–
Power factor	AI	Through network	±10%	±10%	–
Amps (each phase)	AI	Through network	–	–	–

4. Refrigerant Monitor
   a. New connection to existing Chillgard refrigerant monitor

Description	Type	Device	Trend Logging		Calibra-tion
			Comm-issioning	Contin-uous	
Alarm Setpoint – caution	AO	Through network	±100 PPM	±100 PPM	–
Alarm Setpoint – warning	AO	Through network	±100 PPM	±100 PPM	–
Alarm Setpoint – alarm	AO	Through network	±100 PPM	±100 PPM	–
Temperature Tolerance	AO	Through network	±1°F	±1°F	–
Unit failure/trouble alarm	DI	Through network	COV	COV	–
Alarm state (0 to 4)	AI	Through network	COV	COV	–
Refrigerant concentration	AI	Through network	±50 PPM	±50 PPM	F

D. Hardwired Points

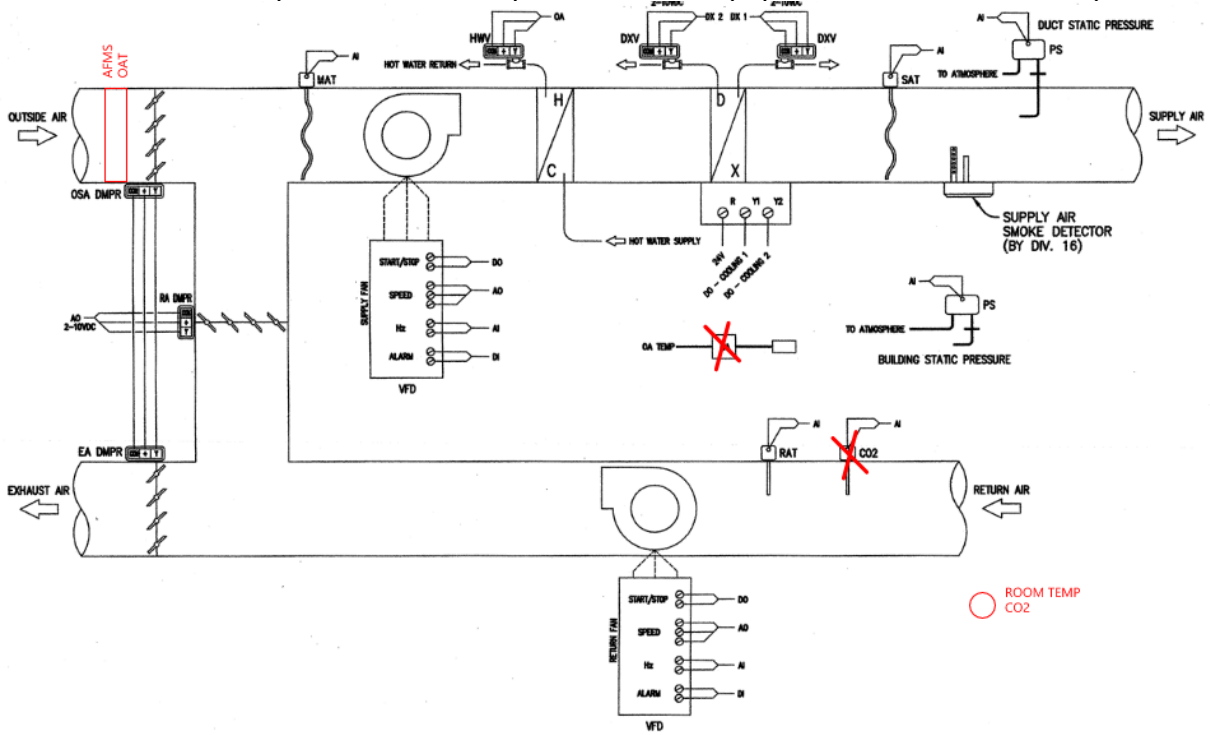
1. VAV Air Handler AC-1 (TCP-1)

a. Schematic

1) Eliminated points

a) Duct mounted CO_2 sensor (replaced with wall mounted)

b) Outdoor air temperature sensor (replaced with AFMS sensor)

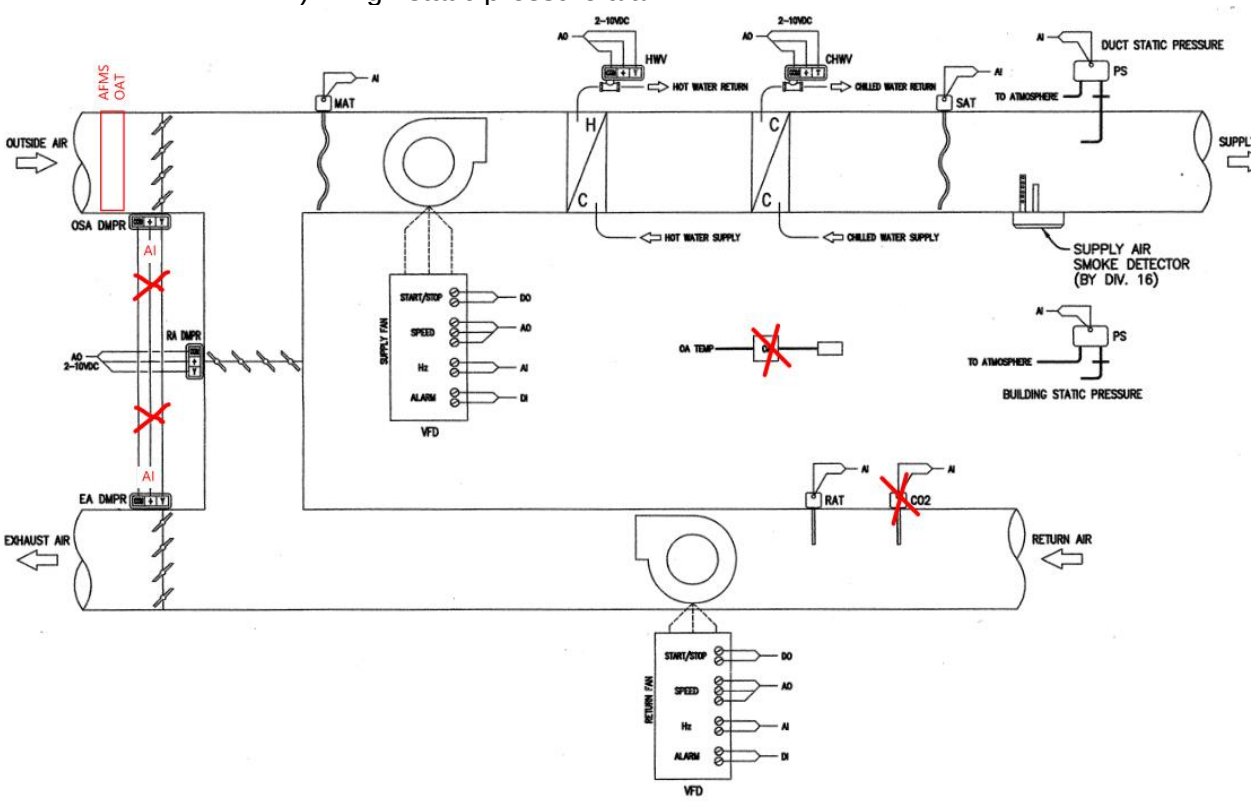


b. Points

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
SF Start/Stop	DO	(E) VFD contact			COV	COV	–
RF Start/Stop	DO	(E) VFD contact			COV	COV	–
SF Speed	AO	(E) VFD contact			1 min	15 min	–
RF Speed	AO	(E) VFD contact			1 min	15 min	–
HW valve	AO	(E) 2-way valve with new actuator	X		1 min	15 min	–
Economizer dampers	AO	(E) dampers with new actuators	X		1 min	15 min	–
Cool stage 1	DO	(E) DX contact			COV	COV	–
Cool stage 2	DO	(E) DX contact			COV	COV	–
SF fault	DI	(E) VFD contact			COV	COV	–
RF fault	DI	(E) VFD contact			COV	COV	–
SF speed feedback	AI	(E) VFD contact			1 min	15 min	–
RF speed feedback	AI	(E) VFD contact			1 min	15 min	–
Building static pressure	AI	Reuse existing			1 min	15 min	F
Mixed air temperature	AI	TS-1B	X		1 min	15 min	F
Supply air temperature	AI	TS-1B	X		1 min	15 min	F
Return air temperature	AI	TS-1A	X		1 min	15 min	F
Supply air static pressure	AI	Reuse existing			1 min	15 min	F
Outdoor airflow	AI	AFMS-4 airflow output	X	X	1 min	15 min	HH
Outdoor temperature	AI	AFMS-4 outdoor air temperature mounted behind louver	X		1 min	15 min	F
Room temperature	AI	TS-3CC located in front of classroom – confirm location via RFI	X	?	1 min	15 min	F
CO_2	AI	TS-3CC. Abandon (E) duct CO_2 sensor	X	X	1 min	15 min	F

2. AH-2, 3 (TCP-2, 3)

a. Schematic
   1) Eliminated points
      a) Damper end switch
      b) Isolation damper – lock damper wide open
      c) CO_2 sensor
      d) Outdoor air temperature sensor (replaced with AFMS sensor)
      e) Low static pressure alarm
      f) High static pressure alarm

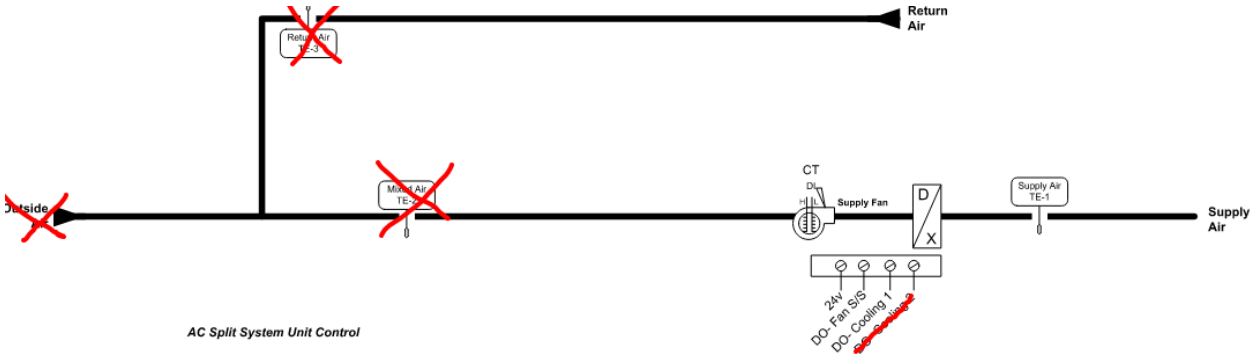


b. Points

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
SF Start/Stop	DO	(E) VFD contact			COV	COV	–
RF Start/Stop	DO	(E) VFD contact			COV	COV	–
SF Speed	AO	(E) VFD contact			1 min	15 min	–
RF Speed	AO	(E) VFD contact			1 min	15 min	–
HW valve	AO	(E) 2-way valve with new NEMA 4 actuator	X		1 min	15 min	–
CHW valve	AO	(E) 2-way valve with new NEMA 4 actuator	X		1 min	15 min	–
Return dampers	AO	(E) dampers with new actuators	X		1 min	15 min	–

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
Relief dampers	AO	(E) dampers with new actuators	X	X	1 min	15 min	−
Outdoor air dampers	AO	(E) dampers with new actuators	X	X	1 min	15 min	−
SF fault	DI	(E) VFD contact			COV	COV	−
RF fault	DI	(E) VFD contact			COV	COV	−
Dirty filter	DI	(E) Magnehelic switch			COV	COV	−
Smoke detector	DI	(E) Smoke detector contact			COV	COV	−
SF speed feedback	AI	(E) VFD contact			1 min	15 min	−
RF speed feedback	AI	(E) VFD contact			1 min	15 min	−
Building static pressure	AI	DPT-4A using existing plate sensor	X		1 min	15 min	F
Return fan discharge pressure	AI	DPT-3A installed at discharge of RF	X	X	1 min	15 min	F
Mixed air temperature	AI	TS-1B	X		1 min	15 min	F
Supply air temperature	AI	TS-1B	X		1 min	15 min	F
Return air temperature	AI	TS-1A	X		1 min	15 min	F
Supply air static pressure	AI	DPT-3A	X		1 min	15 min	F
Outdoor airflow	AI	AFMS-4 airflow output. Demo Ebtron sensor	X	X	1 min	15 min	HH
Outdoor temperature	AI	AFMS-4 outdoor air temperature mounted behind louver	X		1 min	15 min	F

3. ACS-1, 2
    a. Schematic
        1) Eliminated points
            a) Mixed air temperature
            b) Return air temperature

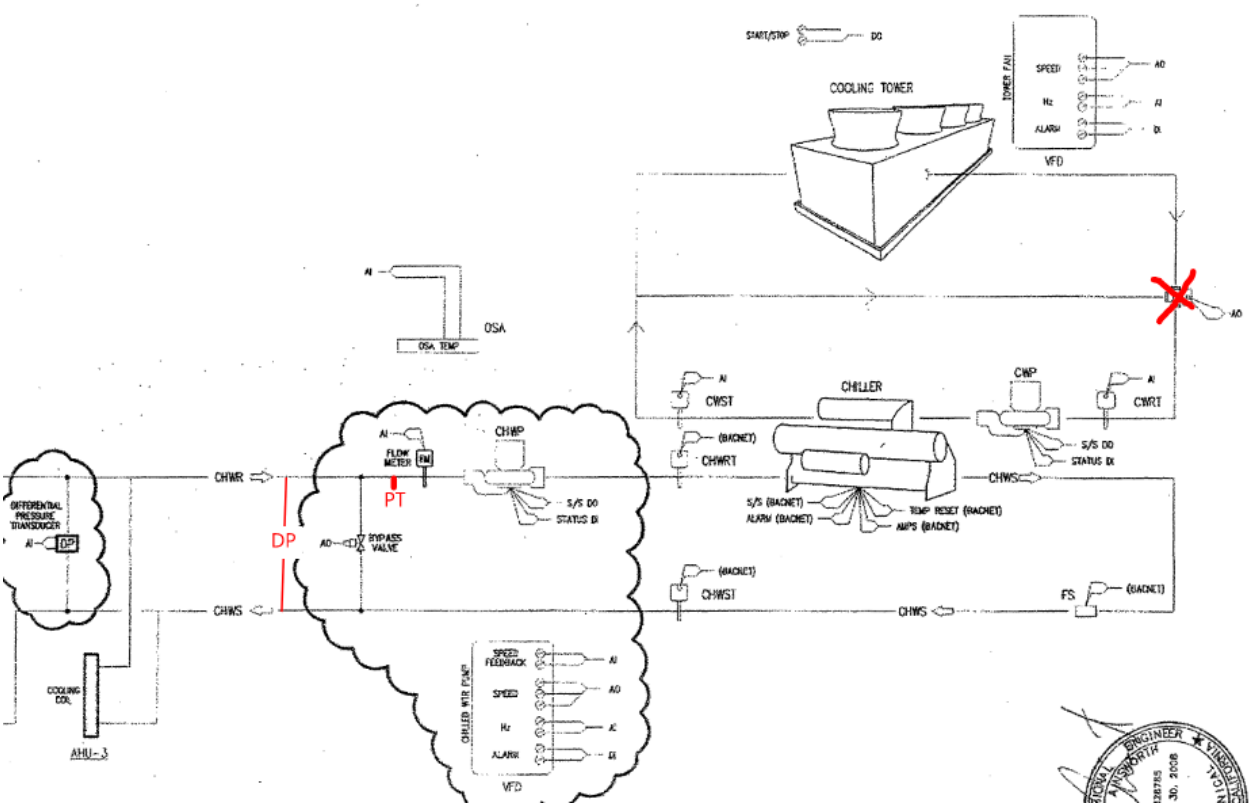


b. Points

Description	Type	Device	New Device	New Point	Trend Logging		Calibra-tion
					Comm-issioning	Contin-uous	
Start Fan	DO	(E) Contact			COV	COV	–
Cooling	DO	(E) Contact			COV	COV	–
Supply fan status	DI	(E) Current switch			COV	COV	–
Supply air temperature	AI	TS-1A	X		1 min	15 min	F
Zone Temperature Setpoint Adjustment	AI	TS-3C			15 min	60 min	F
Zone Temperature	AI	TS-3C			1 min	15 min	F

4. Chiller Plant (TCP-4)

a. Schematic
   1) Eliminated points
      a) Tower bypass. Lock valve in 100% to tower position; remove actuator and control wiring
      b) Refrigerant alarm (if it exists – now through Modbus)
   2) Notes
      a) CH-1 is entirely controlled via BACnet interface
      b) Verify EF-7 is hardwired to refrigerant monitor Alarm (Evacuate) start contact to run at full speed. Fan is not controlled by the BAS.



b. Chiller Plant Points

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
CHW pump Start/Stop	DO	(E) VFD contact			COV	COV	–
CT fan Start/Stop	DO	(E) VFD contact			COV	COV	–
CW pump Start/Stop	DO	(E) starter contact			COV	COV	–
CW Pump Status	DI	CS-1 or CT-1	X	X	COV	COV	See 3.11 F
EF-7	DI	(E) current switch	X	X	COV	COV	–
Cooling tower high level alarm	DI	Contact on level sensor at tower (just being installed by others)		X	COV	COV	–
Cooling tower low level alarm	DI	Ditto		X	COV	COV	–
CHW pump fault	DI	(E) VFD contact			COV	COV	–
CT Fan fault	DI	(E) VFD contact			COV	COV	–
CHW pump speed feedback	AI	(E) VFD contact			1 min	15 min	–

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
CT fan speed feedback	AI	(E) VFD contact			1 min	15 min	–
CHW pump speed	AO	(E) VFD contact			1 min	15 min	–
CT fan speed	AO	(E) VFD contact			1 min	15 min	–
CHW Bypass valve	AO	Modulating valve, sized for 200 gpm minimum flow at ~10 psi DP, in place of existing butterfly valve. Size same as pipe size or close as possible with reducers as required	X	X	1 min	5 min	–
CWS temperature from tower	AI	TS-2A	X		5 min	15 min	F
CWR temperature to tower	AI	TS-2A	X		5 min	15 min	F
CHW supply flow	AI	FM-2 in place of existing insertion turbine	X		5 min	15 min	F
CHW differential pressure at plant	AI	DPT-1, 0 to 40 psi, located at plant	X	X	5 min	15 min	F
CHW differential pressure at AH-2	AI	DPT-1, 0 to 20 psi, located at AH-2, connected to AH-2 TCP – reading transmitted via network	X	X	5 min	15 min	F
CHW system gauge pressure	AI	PT-1, 0 to 60 psi located near expansion tank connection to CHWR	X	X	15 min	1 hr	F
Outdoor air temperature	AI	TS-4	X		5 min	15 min	F
DCW flow (alternate bid only)	AI pulse	1.5” FM-6 or FM-1	X	X	±0.5 gpm	±0.5 gpm	F

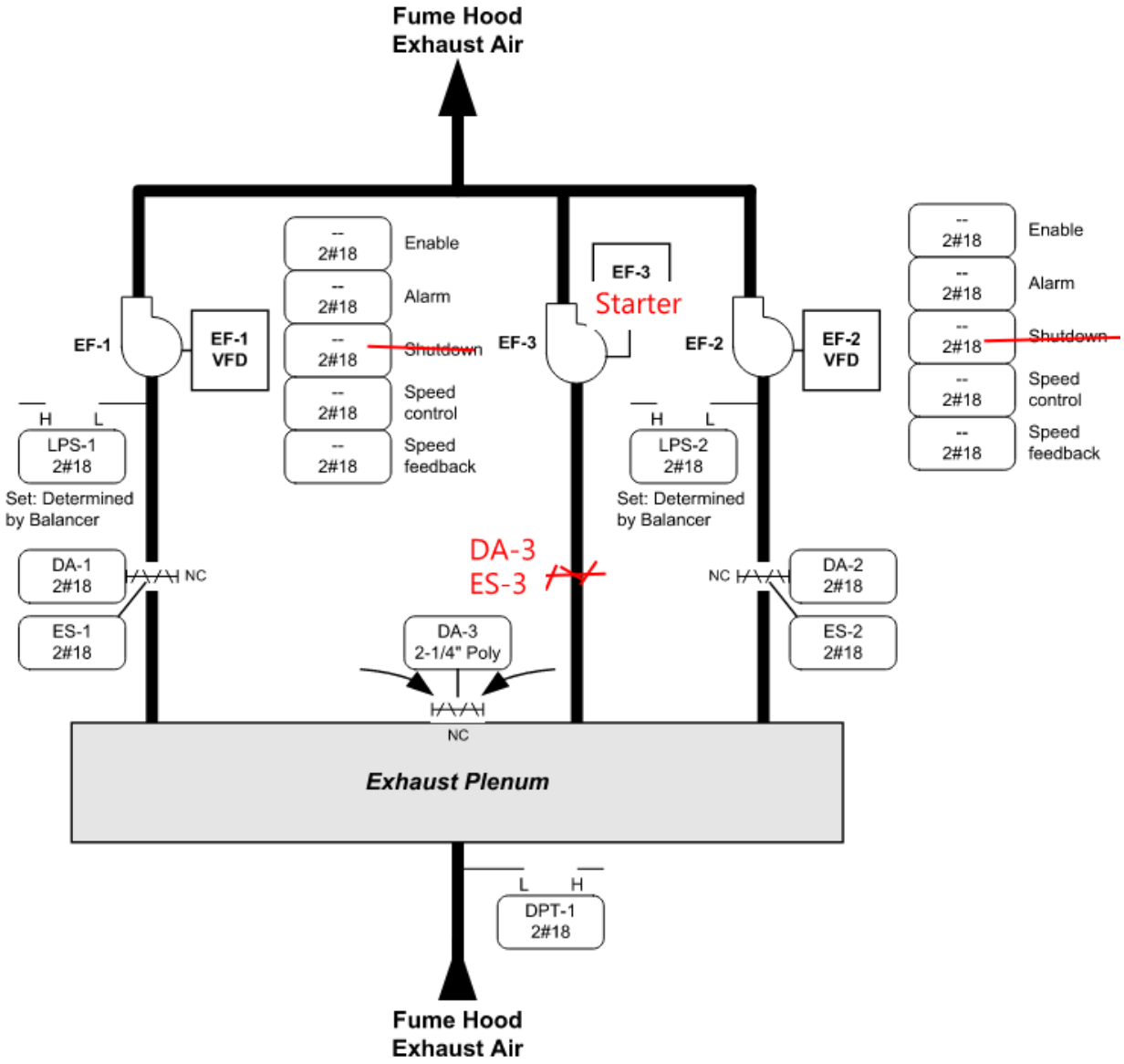
c. New Fan-Coil Points

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
FC fan Start/Stop	DO	Starter contact		X	COV	COV	–
FC fan Status	DI	CS-1 or CT-1	X	X	COV	COV	See 3.11 F
Space temperature	AI	TS-3A	X	X	1 min	15 min	–
CHW valve	AO	(E) 2-way valve		X	1 min	15 min	–

5. Science building monitoring (TCP-MON)
   a. Verify all points in the field

Description	Type	Device	New Device	New Point	Trend Logging		Cali-bra-tion
					Comm-issioning	Contin-uous	
DWP-1 fail	DI	(E) fail contact			COV	COV	–
DWP-2 fail	DI	(E) fail contact			COV	COV	–
DWP-3 fail	DI	(E) fail contact			COV	COV	–
DWP-1 status	DI	(E) CS			COV	COV	–
DWP-2 status	DI	(E) CS			COV	COV	–
DWP-3 status	DI	(E) CS			COV	COV	–
ATS common alarm	DI	(E) alarm contact			COV	COV	–
ATS normal	DI	(E) contact			COV	COV	–
DCW pressure	AI	(E) DPT			15 min	15 min	–

6. Exhaust Air Systems (TCP-5)
   a. LEF Schematic



b. LEF Points

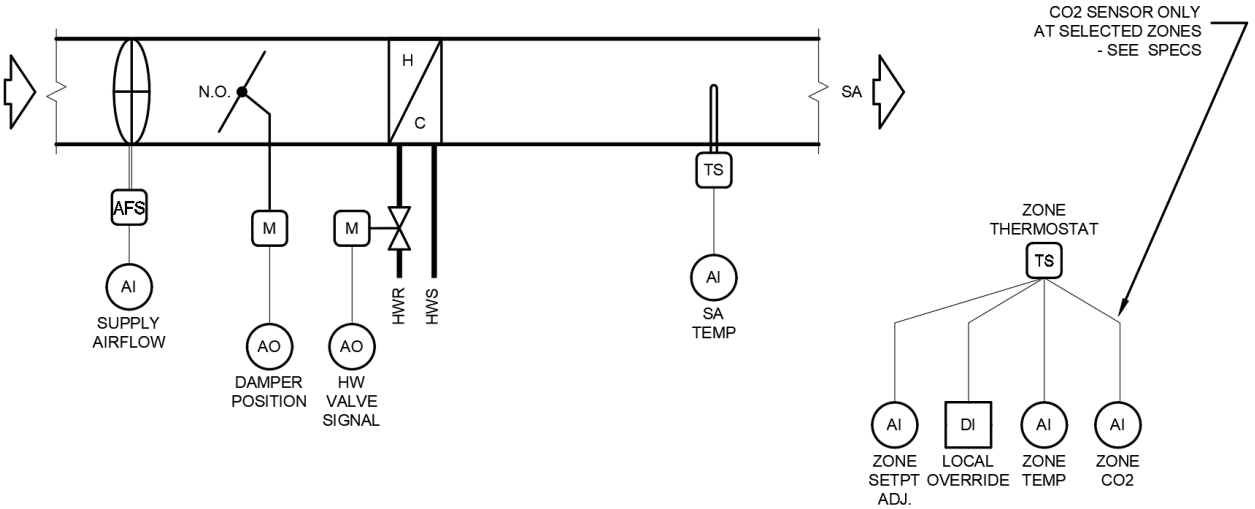
Description	Type	Device	New Device	New Point	Trend Logging		Calibration
					Commissioning	Continuous	
EF-1 start/stop	DO	(E) VFD contact			COV	COV	–
EF-2 start/stop	DO	(E) VFD contact			COV	COV	–
EF-3 start/stop	DO	(E) starter contact			COV	COV	–
EF-1 damper	DO	(E) damper with new actuator	X		COV	COV	–
EF-2 damper	DO	(E) damper with new actuator	X		COV	COV	–
EF-3 damper	DO	(E) damper with new actuator	X		COV	COV	–

Description	Type	Device	New Device	New Point	Trend Logging		Calibration
					Commissioning	Continuous	
Bypass damper	AO	(E) damper with new actuator	X		1 min.	±5%	–
EF-1 fault	DI	(E) VFD contact			COV	COV	–
EF-2 fault	DI	(E) VFD contact			COV	COV	–
EF-3 fan status	DI	(E) current switch			COV	COV	–
EF-1 damper open status	DI	Actuator end switch	X		COV	COV	–
EF-2 damper open status	DI	Actuator end switch	X		COV	COV	–
EF-3 damper open status	DI	Actuator end switch	X		COV	COV	–
EF-1 low pressure switch	DI	(E) DPS			COV	COV	–
EF-2 low pressure switch	DI	(E) DPS			COV	COV	–
EF-1 speed feedback	AI	(E) VFD contact			1 min	15 min	–
EF-2 speed feedback	AI	(E) VFD contact			1 min	15 min	–
Exhaust Plenum static	AI	DPT-3B transmitter, 0 to 5”	X		1 min	15 min	F

c. Other EF Points

Description	Type	Device	New Device	New Point	Trend Logging		Calibration
					Commissioning	Continuous	
EF-4 start/stop	DO	(E) starter contact			COV	COV	–
EF-4 fan status	DI	(E) current switch			COV	COV	–
EF-5 start/stop	DO	(E) starter contact	X	X	COV	COV	–
EF-5 fan status	DI	CS-1 or CT-1	X	X	COV	COV	See 3.11 F
EF-8 start/stop	DO	(E) starter contact			COV	COV	–
EF-8 fan status	DI	(E) current switch			COV	COV	–

7. VAV Box with Reheat
   a. Schematic



b. Revised setpoints: Use the following setpoints instead of those shown on original design drawings. Provide CO_2 sensors in zones indicated. "Old room#" refers to the numbers on design drawings.

Tag	Old Room#	Current Room#	Room Name	Vcool-max	Vmin	Vheat-max	Vocc-min	Varea-min	CO2
2.1	124	124	Corridor	475	AUTO	240	140	140	-
2.2	124	124	Corridor	1550	AUTO	915	125	125	-
2.3	133	139	Cadaver	1020	AUTO	1020	0	1020	-
2.4	132	133	Anatomy Lab	2585	AUTO	2585	0	2585	-
2.5	142	132	Bio Classroom	1995	AUTO	675	675	155	YES
2.6	131	131	Bio Classroom	1910	AUTO	575	540	140	YES
2.7	130	129	Bio Classroom	1910	AUTO	575	540	140	YES
2.10	125	125	Micro Prep/Stock	640	AUTO	640	0	640	-
2.13	144	142	Plant Study	230	AUTO	115	15	15	-
2.14	146	143	Storage	280	AUTO	140	0	15	-
2.15	147	144	Study	345	AUTO	175	120	20	YES
2.16	126	147	Storage	165	AUTO	85	0	15	-
2.17	241	241	Corridor	430	AUTO	215	70	70	-
2.18	234, 244	234, 232	Corridor, office	420	AUTO	210	85	85	-
2.19	227	227	Corridor	740	AUTO	370	125	125	-
2.20	237	242	Storage	125	AUTO	65	0	15	-
2.23	232-233	231-233	Office, Intrument Rm	665	AUTO	300	75	70	-
2.24	231	229	Science Classroom	2065	AUTO	620	480	145	YES
2.25	230	227	Science Classroom	2220	AUTO	665	480	145	YES
2.26	229	225	Tiered Classroom	1825	AUTO	900	900	240	YES
2.28	243	236	Instrument	265	AUTO	135	15	30	-
2.29	245	230	Engineering Lab	1255	AUTO	445	240	170	-

Tag	Old Room#	Current Room#	Room Name	Vcool-max	Vmin	Vheat-max	Vocc-min	Varea-min	CO2
2.30	246	228	Prep/stock	880	AUTO	440	30	160	-
2.31	247	238	Storage	290	AUTO	145	0	10	-
2.32	248	240	Optics	195	AUTO	100	30	35	-
2.33	249	226	Physics	980	AUTO	490	360	175	YES
3.1	101	101	Lobby	1515	AUTO	745	285	285	-
3.2	102	103	Auto-tutorial	1590	AUTO	525	525	160	YES
3.3	102	104	Auto-tutorial	1590	AUTO	525	525	160	YES
3.4	103	105	Group Study	190	AUTO	95	90	20	YES
3.5	104	104	Group Study	490	AUTO	245	120	45	YES
3.6	152	102	Bio Classroom	740	AUTO	720	720	130	YES
3.7	149	110	Storage	180	AUTO	90	15	30	-
3.8	109-110		Corridor/RRs	785	AUTO	435	0	160	-
3.9	111	124	Resource Room	180	AUTO	90	60	30	-
3.10	112	111	Office	260	AUTO	130	15	40	-
3.11	113-115	113-115	Office	425	AUTO	215	45	45	-
3.12	116-118	116-118	Office	420	AUTO	210	45	45	-
3.13	119-121	119-121	Office	420	AUTO	210	45	45	-
3.14	122	122	Storage	475	AUTO	240	15	45	-
3.15	201	201	Lobby	1000	AUTO	445	170	170	-
3.16	203	202	Tech/Media (Quiet)	1925	AUTO	600	600	175	YES
3.17	203	202	Tech/Media (Noisy)	590	AUTO	295	240	80	YES
3.18	204		Astronomy	150	AUTO	75	60	15	YES
3.19	205		Seminar	160	AUTO	90	90	20	YES
3.20	206		Seminar	95	AUTO	75	75	20	YES
3.21	208	206	Seminar	120	AUTO	90	90	30	YES
3.22	210	208	Seminar	180	AUTO	90	90	35	YES
3.23	207	207	Corridor	615	AUTO	305	110	110	-
3.24	211-212		Corridor/RRs	850	AUTO	480	0	165	-
3.25	226	223	Resource Room	200	AUTO	100	60	35	-
3.26	225	222	Conference	235	AUTO	120	120	40	YES
3.27	215	211	Office	175	AUTO	90	15	15	-
3.28	216-217	213-214	Office	490	AUTO	245	30	25	-
3.29	218-220	215-217	Office	735	AUTO	300	45	45	-
3.30	221-223	218-220	Office	735	AUTO	300	45	45	-
3.31	224	221	Office	735	AUTO	300	45	45	-

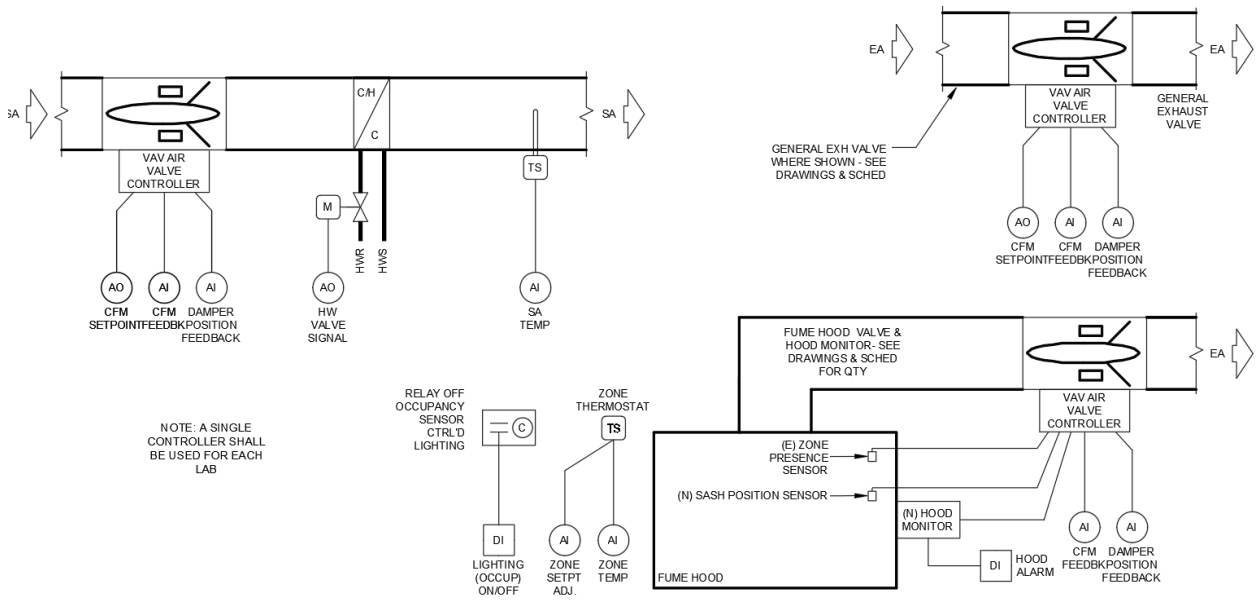
c. Points

Description	Type	Device	New Device	New Point	Trend Logging		Calibration
					Commissioning	Continuous	
VAV Box Damper Position	AO	Modulating analog actuator	X		1 min	15 min	–
HW valve signal	AO	(E) 2-way valve body with new actuator	X		1 min.	15 min	
Local Override	DI	TS-3C or TS-3CC	X		COV	COV	–
Supply Airflow	AI	DPT-5 connected to existing box manufacturer supplied flow cross	X		1 min	15 min	HH
Supply air temperature	AI	Existing	X		1 min	15 min	F
Zone Temperature Setpoint Adjustment	AI	TS-3C or TS-3CC	X		15 min	60 min	F
Zone Temperature	AI	TS-3C or TS-3CC	X		1 min	15 min	F
Zone CO_2 concentration	AI	TS-3CC where indicated in schedule above	X	X	1 min	15 min	F

d. Auxiliary Points

Description	Type	Device	New Device	New Point	Trend Logging		Calibration
					Commissioning	Continuous	
Electrical room 138 temperature	AI	(E) thermistor tied to VAV 2.4			1 min	15 min	

8. Lab Zones
   a. Use one controller per lab so that network operation does not affect lab performance.
   b. Schematic



c. Revised setpoints. Use the following setpoints instead of those shown on original design drawings. "Old room#" refers to the numbers on design drawings. See original design schedule for hood maximum and minimum setpoints, which shall be configured into the new hood air valves.

Tag	Old Room #	Current Room#	Room Name	Vmax	Vcool-max	Vmin-occ	Vmin-unocc	Voffset	Vgex-max	Vol-ume	Hood Valve Qty	Cabinet Valve Qty
2.8	143	130	Majors Bio Lab	1680	1680	1530	970	-150	1570	16800	1	0
2.9	129	127	Microbio Lab	1770	1770	1620	1030	-150	1670	17700	1	0
2.11	148	126	General Bio Lab	1650	1650	1500	950	-150	1535	16500	1	0
2.12	145	128	Bio prep	750	750	600	350	-150	535	7500	1	1
2.21	236	237	Chem Prep	1520	1190	950	585	-150	740	11010	2	0
2.22A -D	235	235	Organic Chem Lab	10400	4750	1435	905	-150	0	15830	17	0
2.27	242	234	General Chem Lab	3640	1875	1460	925	-150	525	16100	5	0

d. Points

Description	Type	Device	New Device	New Point	Trend Logging		Calibra-tion
					Comm-issioning	Contin-uous	
Hood alarm (any hood)	DI	Connect to new hood monitor alarm contact, in parallel if more than one hood	X	X	COV	COV	–
Occupancy	DI	Relay connected to light fixture controlled by occupancy sensor	X	X	COV	COV	–

Description	Type	Device	New Device	New Point	Trend Logging		Calibra-tion
					Comm-issioning	Contin-uous	
Presence sensor	DI	Reuse (E) Zone presence sensor & power supply			COV	COV	–
Supply airflow setpoint	AO	To air valve	X		1 min	15 min	–
General exhaust airflow setpoint	AO	To air valve	X		1 min	15 min	–
HW valve position	AO	(E) 2-way valve body with new actuator	X		1 min.	15 min	
Supply Airflow	AI	Air valve CFM feedback	X		1 min	15 min	F
Supply Damper position	AI	Air valve damper position feedback	X		1 min	15 min	F
General Exhaust Airflow	AI	Air valve CFM feedback	X		1 min	15 min	F
General Exhaust Damper position	AI	Air valve damper position feedback	X		1 min	15 min	F
Hood Exhaust Airflow (each hood)	AI	Air valve CFM feedback	X		1 min	15 min	F
Hood Exhaust Damper position (each hood)	AI	Air valve damper position feedback	X		1 min	15 min	F
Supply air temperature	AI	TS-1A	X		1 min	15 min	F
Zone Temperature Setpoint Adjustment	AI	TS-3C	X		15 min	60 min	F
Zone Temperature	AI	TS-3C	X		1 min	15 min	F

9. Plumbing Equipment Room 123

Description	Type	Device	New Device	New Point	Trend Logging		Calibra-tion
					Comm-issioning	Contin-uous	
Industrial HW pump	DO	(E) starter contact			COV	COV	−
Domestic HW pump	DO	(E) starter contact			COV	COV	−
Industrial HW pump status	DI	(E) current switch			COV	COV	−
Domestic HW pump status	DI	(E) current switch			COV	COV	−
IHW supply temperature	AI	TS-2A	X		1 min	15 min	F

Description	Type	Device	New Device	New Point	Trend Logging		Calibra-tion
					Comm-issioning	Contin-uous	
DHW supply temperature	AI	TS-2A	X		1 min	15 min	F
DCW flow (alternate bid only)	AI pulse	4” FM-6 or FM-1	X	X	±0.5 gpm	±0.5 gpm	F
Natural gas flow (alternate bid only)	AI pulse	2” FM-3B	X	X	±0.5 gpm	±0.5 gpm	F

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

A. Install systems and materials in accordance with manufacturer’s instructions, roughing-in drawings and details indicated on Drawings.

B. Coordinate Work and Work schedule with other trades prior to construction.

C. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.

B. Store equipment and materials inside and protect from weather.

3.3 IDENTIFICATION

A. General

1. Manufacturers’ nameplates and UL or CSA labels to be visible and legible after equipment is installed.

2. Identifiers shall match record documents.

3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring and Tubing

1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2 inches of termination with the BAS address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3. All pneumatic tubing shall be labeled at each end within 2 inches of termination with a descriptive identifier.

C. Equipment and Devices

1. Valve and damper actuators: None required.

2. Sensors: Provide 1 inch x 3 inches x 1/8 inches black micarta or lamacoid labels with engraved white lettering, ¼ inches high. Indicate sensor identifier and function (for example “CHWS Temp”).

3. Panels
   a. Provide 2 inches x 5 inches 1/8 inches black micarta or lamacoid labels with engraved white lettering, ½ inches high. Indicate panel identifier and service.
   b. Provide permanent tag indicating the electrical panel and circuit number from which panel is powered.

4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.4 CUTTING, CORING, PATCHING AND PAINTING

A. Provide canning for openings in concrete walls and floors and other structural elements prior to their construction.

B. Penetrations through rated walls or floors shall be filled with a listed material to provide a code compliant fire-stop.

C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Work in this Section shall be properly sealed, repaired, or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of Work, all equipment furnished under this Section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.5 CLEANING

A. Clean up all debris resulting from its activities daily. Remove all cartons, containers, crates, and other debris generated by Work in this Section as soon as their contents have been removed. Waste shall be collected and legally disposed of.

B. Materials stored on-site shall be protected from weather and stored in an orderly manner, neatly stacked, or piled in the designated area assigned by the College’s Representative.

C. At the completion of work in any area, clean all work and equipment of dust, dirt, and debris.

D. Use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.6 CONTROLLERS

A. General

1. Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details indicated on Drawings.

2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.
   a. Global points such as outdoor air temperature
   b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants
   c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones

3. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

B. Controller Application Categories

1. Controllers shall comply with the application table below (X under controller type indicates acceptable controller type).

Application Category	Examples	Acceptable Controller		
		ASC	AAC	BC
0	Monitoring of variables that are not used in a control loop, sequence logic, or safety, such as status of sump pumps or associated float switches, temperatures in monitored electrical rooms.	X	X	X
1	Constant speed exhaust fans and pumps	X	X	X
2	VAV Zones Unitary AC and HP units	X		
3	Air Handling Units Lab Exhaust Fans Lab Zones		X (note 1)	X
4	Chilled Water Plant		X (note 1)	X

Application Category	Examples	Acceptable Controller		
		ASC	AAC	BC
Notes: 1. Controller may be used only if all control functions and physical I/O associated with a given unit resides in one AAC/ASC 2. There shall be at least one BC in the system.				

2. ASC Installation
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

3. AAC and BC Installation
   a. AACs/BCs shall be located in a temperature control cabinets constructed per Paragraph 2.8.

3.7 COMMUNICATION DEVICES

A. General

1. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details indicated on Drawings.

2. Provide all interface devices and software to provide an integrated system.

B. LANID and LAN Routers

1. Provide as required

2. Connect networks to both sides of device

3. Thoroughly test to ensure proper operation

4. Interruptions or fault at any point on any Primary LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

C. Gateways and Protocol Translators to Equipment Controllers

1. See Paragraph 2.4C for network connection of Gateways and Protocol Translators.

2. Wire to networks on both sides of device.

3. Map across all monitoring and control points listed in Paragraph 2.13C.

4. Thoroughly test each point to ensure that mapping is accurate.

5. Initiate trends of points as indication in Paragraph 2.13C.

3.8 CONTROL AIR TUBING

A. Sensor air tubing shall be sized by the Contractor.

B. All control air piping shall be concealed except in equipment rooms or unfinished areas.

C. Installation methods and materials

1. Concealed and Inaccessible: Use copper tubing or FR plastic in metal raceway. Exception: Room thermostat drops in stud walls in areas with lay-in ceiling may be FR plastic tubing.

2. Concealed and Accessible tubing (including ceiling return air plenums) shall be copper tubing or FR plastic tubing, subject to the following limitations
   a. FR tubing shall be enclosed in metal raceway when required by local code.
   b. Quantity of FR tubing per cubic foot of plenum space shall not exceed manufacturer's published data for Class 1 installation.

3. Exposed to view or damage: Use hard-drawn copper or FR plastic in metal raceway.
   a. Where copper tubing is used, a section 12 inches or less of FR plastic tubing is acceptable at final connection to control device.

D. Mechanically attach tubing to supporting surfaces. Sleeve through concrete surfaces in minimum 1 inch sleeves, extended 6 inches above floors and 1 inch below bottom surface of slabs.

E. Pneumatic tubing shall not be run in raceway containing electrical wiring.

F. Where FR tubing exits the end of raceway or junction box, provide a snap-in nylon bushing. Where pneumatic tubing exits control panels, provide bulkhead fittings. Where copper tubing exits junction boxes or panels, provide bulkhead fittings.

G. All tubing shall be number coded on each end and at each junction for easy identification.

H. All control air piping shall be installed in a neat and workmanlike manner parallel to building lines with adequate support.

I. Piping above suspended ceilings shall be supported from or anchored to structural members or other piping or duct supports. Tubing shall not be supported by or anchored to electrical raceways or ceiling support systems.

J. Brass-barbed fittings shall be used at copper-to-FR tubing junctions. Plastic slipped-over copper tubing is not acceptable.

K. Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.9 CONTROL POWER

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section. Do not exclude this work – there is no other electrical contractor. Subcontract electrical work if required.

B. Existing 120V power connections may be reused.

C. Extend power to all new BAS devices, including 120V power to panels, from an acceptable power panel.

D. General requirements for obtaining power include the following:

1. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it.

2. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120V source fed from a common origin.

3. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or not of the correct voltage to supply the controls, provide separate transformer(s).

4. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, or interruptible), the controller, and any associated switches and devices necessary its operation, shall be powered by the highest level of reliability served.

E. Unless transformers are provided with equipment, Contractor shall provide transformers for all low voltage control devices including non-powered terminal units such as VAV boxes. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

F. Power line filtering. Provide transient voltage and surge suppression for all workstations and BCs either internally or as an external component.

3.10 CONTROL AND COMMUNICATION WIRING

A. Control and Signal Wiring

1. Line Voltage Wiring
   a. All line-voltage wiring shall meet NEC Class 1 requirements.
   b. All Class 1 wiring shall be installed in UL Listed approved raceway per NEC requirements and shall be installed by a licensed electrician.
   c. Class 1 wiring shall not be installed in raceway containing pneumatic tubing.

2. Low Voltage Wiring
   a. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
   b. Class 2 wiring shall be installed in UL Listed approved raceway as follows:
      1) Where located in unconcealed or inaccessible locations, such as:
         a) Equipment rooms
         b) Exposed to weather
         c) Exposed to occupant view
         d) Inaccessible locations such as concealed shafts and above inaccessible ceilings
      2) Class 2 wiring shall not be installed in raceway containing Class 1 wiring.
   c. Class 2 wiring need not be installed in raceway as follows:
      1) Where located in concealed and easily accessible locations, such as:
         a) Inside mechanical equipment enclosures and control panels
         b) Above suspended accessible ceilings (e.g. lay-in and spline)
         c) Above suspended drywall ceilings within reach of access panels throughout
         d) In shafts within reach of access panels throughout
         e) Nonrated wall cavities
      2) Wiring shall be UL Listed for the intended application. For example, cables used in floor or ceiling plenums used for air transport shall be UL Listed specifically for that purpose.
      3) Wiring shall be supported from or anchored to structural members neatly tied at 10 foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.
      4) Install wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
   d. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

3. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

4. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.

5. Use coded conductors throughout with different colored conductors.

6. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

7. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.

8. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

9. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendation and NEC requirements.

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

11. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

12. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).

13. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

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

15. Terminate all control or interlock wiring.

16. Maintain updated as-built wiring diagrams with terminations identified at the jobsite.

17. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inches electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.

18. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings per code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

19. Shielded cable shield shall be grounded only at one end. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

B. Communication Wiring

1. Adhere to the requirements of Paragraph 3.10A in addition to this Paragraph.

2. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted by Paragraph 3.10A only if noise immunity is ensured. Contractor is fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.

3. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers' installation recommendations for all communication cabling.

4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

5. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.

6. Verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

7. All runs of communication wiring shall be unspliced length when that length is commercially available.

8. All communication wiring shall be labeled to indicate origination and destination data.

9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable and Protector Grounding.

10. Power-line carrier signal communication or transmission is not acceptable.

3.11 SENSORS AND MISCELLANEOUS FIELD DEVICES

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Sensors used as controlled points in control loops shall be hardwired to the controller to which the controlled device is wired and in which the control loop shall reside.

D. Temperature Sensors

1. Room temperature sensors and thermostats shall be installed with back plate firmly secured to the wall framing or drywall anchors.
   a. For sensors mounted in exterior walls or columns, use a back plate insulated with foam and seal all junction box openings with mastic sealant.
   b. For sensors on exposed columns, use Wiremold or equal enclosures that are the smallest required to enclose wiring (e.g. Wiremold 400 BAC or equal) and Wiremold or equal junction boxes that are the narrowest required to enclose the temperature sensor and wiring connections (e.g. Wiremold 2348S/51 or

equal). Color or raceway and boxes shall be per the architect; submit for approval prior to installation.

2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (such as mixed air sensors), access for filter removal shall be maintained.

4. Temperature sensors downstream of coils shall be located as far from the coil fins as possible, 6 inches minimum. Temperature sensors upstream of coils shall be a minimum of 6 inches away from the coil fins. No part of the sensor or its support elements or conduit shall be in contact with the coil, coil framing or coil support elements. Discharge temperature sensors on VAV boxes shall be mounted as far from the coil as possible but upstream of the first diffuser with the probe located as near as possible to the center of the duct both vertically and horizontally.

5. All pipe-mounted temperature sensors shall be installed in wells. For small piping, well shall be installed in an elbow into pipe length. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.

6. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO_2 sensors, and other room wall mounted sensors shall be installed at same centerline elevation as adjacent electrical switches, 4 feet above the finished floor where there are no adjacent electrical switches, and within ADA limitations.

7. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to either
         a) Building pressure (high) signal of the building static pressure transmitter.
         b) Open to a conditioned space inside the building
         c) Open to the BAS panel in which the DPT is mounted provided the panel is inside the building envelope and not in an air plenum.
   c. High-pressure port of the pressure sensor

1) Pipe to the duct using a static pressure tip located as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers.
2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions.

2. Return Fan Discharge Plenum Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to either
         a) Building pressure (low) signal of the building static pressure transmitter.
         b) Separate ambient static pressure probe located on the outside of the relief damper through a high-volume accumulator or otherwise protected from wind fluctuations.
   c. High-pressure port of the pressure sensor
      1) Pipe to the duct using a static pressure tip located at the discharge of the return fan.
      2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions.

3. Building Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.
   c. High-pressure port of the pressure sensor
      1) Pipe to either
         a) Behind a BAS temperature sensor cover in an interior zone (provided sensor has openings to allow ambient air to freely flow through it)
         b) Wall plate sensor or wall/ceiling probe sensor as scheduled
      2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

4. Filter Differential Pressure
   a. Reuse existing

5. All pressure transducers, other than those controlling VAV boxes, shall be located where accessible for service without use of ladders or special equipment. If required, locate in field device panels and pipe to the equipment monitored or ductwork.

6. The piping to the pressure ports on all pressure transducers (both air and water) shall contain a capped test port located adjacent to the transducer.

7. Piping differential pressure transducers shall have one of the following:

a. Five valve manifold, brass, two valves to allow removal of sensor without disrupting the hydronic system, an equalizing valve to allow the sensor to be zeroed and to prevent sensor from experiencing full static (as opposed to differential), and two valves used as air vents that also can be used as test plugs for calibration.
b. For sensors using two separate sensors, install test plugs on each connection for calibration and also used as vents.

F. Current Switches and Current Transformers for Motor Status Monitoring

1. For CTs, create a software binary point for fan status triggered at a setpoint determined below and ~10% deadband.

2. Adjust the setpoint so that it is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running. For pumps, adjust so that pump indicates off if valve is closed while pump is running.

G. Airflow Measuring Stations: Install per manufacturer's recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

H. Fluid Flow Meters: Install per manufacturer's recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer's startup and commissioning recommendations. Complete all manufacturer's startup documentation and include this in prefunctional commissioning report.

I. Actuators

1. Type: All actuators shall be electric.

2. Mount and link control damper actuators per manufacturer's instructions.

3. Dampers
a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturer's instructions to achieve same effect.
b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
c. Provide all mounting hardware and linkages for actuator installation.

4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, mount the valve so that the position indicator is visible from the floor or other readily accessible location. However, do not install valves with stem below horizontal or down. The preferred location for the valve and actuator is on lowest point in the valve train assembly

for ease of access and inspection. If this is on the coil supply piping, the control valve may be located there even if schematics (and standard practice) show valves located on the coil return piping. This comment applies to both 2−way valves and 3-way valves (which would become diverting valves rather than mixing valves in this location).

J. Laboratory Fume Hoods:

1. Install fume hoof monitor in knock-out opening provided with hood in place of existing monitor.

2. Install sash sensors on each VAV fume hood in place of existing sash sensor. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels.

3. Configure hood air valve with maximum and minimum setpoints as indicated on original Mechanical Drawings. Setpoint when presence sensor indicates no occupancy shall be 60% of maximum airflow.

3.12 SOFTWARE INSTALLATION

A. System Configuration

1. Thoroughly and completely configure BAS system software, supplemental software, network software etc. on servers.

B. Point Structuring and Naming

1. The intent of this Paragraph is to require a consistent means of naming points across the BAS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.

2. Point Summary Table
   a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.
   b. With each schematic, provide a Point Summary Table listing
      1) Building number and abbreviation
      2) System type
      3) Equipment type
      4) Point suffix
      5) Full point name (see Point Naming Convention Paragraph)
      6) Point description
      7) Ethernet backbone network number
      8) Network number
      9) Device ID
      10) Device MAC address
      11) Object ID (object type, instance number)
      12) Engineering units
      13) Device make and model number; include range of device if model number does not so identify.

14) Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).

c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).
d. Coordinate with the College's representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.
e. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the College the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

3. Point Naming Convention
   a. All point names shall adhere to the format as established below, unless otherwise agreed to by the College. New categories and descriptors may be created with approval of the College.
   b. Format:
      1) Building.Category.System.EquipmentTag.Component.Property.
      2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature

Building	Category	System	Equipment Tag	Component	Property	Typical units
Campus/ Building number	ELCT	Lighting Plug Generator Misc	(from equipment schedules)	SWITCH PHOTO CB CWS CWR HWS HWR CHWS CHWR OA SA RA EA GAS FLUID	Command Status Light Power Voltage Current ValvePos DamperPos Temperature Humidity Pressure Flow Energy Speed Signal	On/off On/off Footcandles Watts Volts Amps %open %open °F %RH Psig, "H_2O Cfm, gpm Btu %, Hz %
	HVAC	Airhandling Exhaust Heatplant Coolplant Misc				
	PLMB	Domwater Air Natgas N2 O2 Irrigation Waste Misc				
	MISC	Weather				

4. Device Addressing Convention
   a. BACnet network numbers and Device Object IDs shall be unique throughout the network.
   b. All assignment of network numbers and Device Object IDs shall be coordinated with the College to ensure there are no duplicate BACnet device instance numbers.

c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner: VVVNN, where: VVV = 0-999 for BACnet Vendor ID, NN = 00 - 99 for building network.
d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner: VVVNNDD , where: VVV = number 0 to 999 for BACnet Vendor ID , NN = 00 - 99 for building network, DD = 01-99 for device address on a network.
e. Coordinate with the College or a designated representative to ensure that no duplicate Device Object IDs occur.
f. Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the College.

5. I/O Point Physical Description
   a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:
      1) The device manufacturer and model number. Include range of device if model number does not so identify.
      2) For space sensors, include room number in which sensor is located.

C. Point Parameters

1. Provide the following minimum programming for each analog input
   a. Name
   b. Address
   c. Scanning frequency or COV threshold
   d. Engineering units
   e. Offset calibration and scaling factor for engineering units
   f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
   g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the Primary or Secondary networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.

2. Provide the following minimum programming for each analog output
   a. Name
   b. Address
   c. Engineering units
   d. Offset calibration and scaling factor for engineering units
   e. Output Range
   f. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
   d. Debounce time delay
   e. Message and alarm reporting as specified

f. Reporting of each change of state, and memory storage of the time of the last change of state
g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

4. Provide the following minimum programming for each digital output
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units (on/off, open/closed, freeze/normal, etc.)
   e. Direct or Reverse action selection
   f. Minimum on-time
   g. Minimum off-time
   h. Status association with a DI and failure alarming (as applicable)
   i. Reporting of each change of state, and memory storage of the time of the last change of state.
   j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
   k. Default value to be used when the normal controlling value is not reporting.

D. Site-Specific Application Programming

1. All site specific application programming shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:
   a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
   b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
   c. Programs are thoroughly debugged before they are installed in the field.

2. Massage and tune application programming for a fully functioning system. It is the Contractor's responsibility to request clarification on sequences of operation that require such clarification.

3. All site-specific programming shall be fully documented and submitted for review and approval
   a. Prior to downloading into the panel (see Submittal Package 2, Paragraph 1.9.)
   b. At the completion of functional performance testing, and
   c. At the end of the warranty period (see Warranty Maintenance, Paragraph 1.14).

4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the College and shall remain on the workstations/servers at the completion of the Project.

E. Graphic Screens

1. All site specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.

2. Graphics shall conform to 4CD ALC standards. See Sample Graphics herein and also recently completed projects such as CCC Science Building. Existing Andover graphics are unacceptable so do not use them as templates.

3. Schematics of MEP systems
   a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided herein.
   b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
   c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.
   d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

4. Displays shall show all points relevant to the operation of the system, including setpoints.

5. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

6. Show weather conditions (local building outside air temperature and humidity) in the upper left hand corner of every graphic.

7. CAD Files: The architectural drawings will be made available to the Contractor in AutoCAD format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However the College does not guarantee the suitability of these drawings for the Contractor’s purpose.

8. Provide graphics for the following as a minimum
   a. Site homepage: Background shall be a campus map, approximately to scale. Include links to each building, central plant, etc.
   b. Building homepage: Background shall be a building footprint, approximately to scale, oriented as shown on the campus homepage. Include links to each floor and mechanical room/area, and to summary graphics described below. Include real-time site utility data such as building electrical demand and domestic cold water flow shown roughly on the map where the utilities connect to the site.
   c. Electricity demand limiting
      1) Demand limit. Include entries for sliding window interval and a table of Off-Peak, On-Peak or Partial-Peak demand time periods, both Summer and non-Summer, with three adjustable demand level limits for each and adjustable deadband.
      2) Electricity demand calculation. For each month, show actual peak kW and kWh for each time-of-day rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data.

d. Each occupied floor plan, to scale
   1) HVAC: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual comfort condition changes. In each zone, provide links to associated terminal equipment.
   2) If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
e. Each equipment floor/area plan: To scale, with links to graphics of all BAS controlled/monitored equipment.
f. Each air handler: Provide link to associated HW and CHW plants where applicable.
g. Each trim & respond reset: Next to the display of the setpoint that is being reset, include a link to page showing all trim & respond points (see Guideline 36) plus the current number of requests, current setpoint, and status indicator point with values "trimming," "responding," or "holding." Include a graph of the setpoint trend for the last 24 hours. Trim & respond points shall be adjustable from the graphic except for the associated device.
h. Each zone terminal
   1) See Sample Graphics – VAV Reheat Zone
   2) Include a non-editable graphic (picture) showing the design airflow setpoints from the design drawings adjacent to the editable airflows setpoints. The intent is that the original setpoints be retained over time despite "temporary" adjustments that may be made over the years.
i. Each lab zone terminal:
   1) Provide link to associated air handling unit where applicable and to floor plan where terminal is located.
   2) Include supply air temperature from AHU serving terminal unit.
   3) Include a non-editable graphic (picture) showing the design airflow setpoints from the design drawings adjacent to the editable airflows setpoints. The intent is that the original setpoints be retained over time despite "temporary" adjustments that may be made over the years.
   4) Include room air change rate calculated from zone volume and either supply airflow rate if differential is positive, or exhaust airflow rate if differential is negative.
j. Electrical power monitoring system: Show side-by-side kWh and peak demand as month-this-year and month-last-year, and month-to-date and year-to-date data.
k. Water meters (alternate bid): Show side-by-side gallons and peak demand gpm as month-this-year and month-last-year, and month-to-date and year-to-date data.
l. Energy Monitoring Dashboard: Show kWh, kW, Gallons, Therms for each of the end uses being metered on a Day, Month and Year chart. Use the standard District template from ALC as the template – see Sample Graphics herein.
m. Central plant equipment including chilled water system, cooling tower system, etc.: The flow path shall change on the diagram (by changing piping line

color or width) to show which piping has active flow into each chiller, tower, etc. as valve positions change.

n. Summary graphics: Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment. Include hyperlinks to each zone imbedded in the zone tag:
   1) Air handling units: operating mode; on/off status; supply air temperature; supply air temperature setpoint; fan speed; duct static pressure; duct static pressure setpoint; outdoor air and return air damper position; coil valve positions; etc. (all key operating variables); Cooling CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Heating HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier (if HW coil)
   2) Zone Groups
      a) Separate zone terminal summary for each Zone Group.
      b) See Sample Graphics –Zone Group Summary herein
   3) Lab Zone terminal units: operating mode; supply airflow rate; supply airflow rate setpoint; zone temperature; active heating setpoint; active cooling setpoint; supply air temperature; supply air temperature setpoint; fume hood status; exhaust airflow rate; Supply Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Exhaust Static Pressure Reset current requests, cumulative %-request-hours, and request Importance Multiplier; Cooling SAT Reset current requests, cumulative %-request-hours, and request Importance Multiplier; CHWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier; HWST Reset current requests, cumulative %-request-hours, and request Importance Multiplier.

o. For all equipment with runtime alarms specified, show on graphic adjacent to equipment the current runtime, alarm setpoint (adjustable), alarm light, date of last runtime counter reset, and alarm reset/acknowledge button which resets the runtime counter.
p. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.
q. All other BAS controlled/monitored equipment.
r. On all system graphics, include a “note” block that allows users to enter comments relevant to system operation.
s. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

F. Alarm Configuration

1. Program alarms and alarm levels per Sequence of Operations.

2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).

3. For initial setup, Contractor shall configure alarms as follows:

	Level 1	Level 2	Level 3	Level 4
Criticality	Critical	Not Critical	Not Critical	Not Critical
Acknowledgement	Required	Required	Not Required	Not Required
Acknowledgement of Return to Normal	Not Required	Not Required	Not Required	Not Required
Email to building engineer(s)	Y	Y	Y	N
SMS text to building engineer(s)	Y	Y	N	N
Pop-up dialog box on OWS	Y	Y	N	N
Remove from alarm log	After Acknowledged	After Acknowledged	After 2 weeks	After 2 weeks

3.13 SEQUENCES OF OPERATION

A. See Section 259000 Building Automation Sequences of Operation.

3.14 TESTING, ADJUSTING, AND BALANCING

A. Testing, adjusting, and balancing (TAB) shall be performed in complete accordance with AABC or NEBB National Standards for Field Measurements and Instrumentation as applicable to air distribution and hydronic systems.

B. AC-1

1. Airflow Readings
   a. Total supply air quantities shall be determined at all of the following where applicable
      1) Pitot traverse in the supply duct downstream, positive pressure side of the fan
      2) Pitot traverse at coil or filter bank
      3) Totaling the readings of individual terminals as read through the BAS
   b. Total return air quantities shall be determined at all of the following where applicable
      1) Pitot traverse in the return air duct entering air handler
   c. Outside air quantities shall be determined by all of the following where applicable
      1) Subtracting pitot traverses of supply and return ducts
      2) Outdoor airflow sensor reading as read through the BAS

2. Adjust fan speed using manual adjustment of variable speed drive for testing only. Do not change or adjust sheaves.

3. Outside air flow measuring station calibration
   a. Test Conditions
      1) Override the economizer to 100% outdoor air, i.e. configure the outdoor air damper to be 100% open and the return air damper to be 0% open.

2) Start supply fan and run it slowly from 20% speed up to 100% speed, in 20% increments with a pause at each step to allow time for the VAV boxes to communicate. At each 20% increment, measure and report:
   a) Sum of VAV box airflows as displayed on BAS AHU graphic
   b) Airflow measurement station airflow reading
   c) Traverse across supply air duct, filter bank, or other location where the most accurate airflow reading is possible

b. Plot the speed vs. all three measured airflows. They should be linear and the three readings should be within 10% of each other.
c. Coordinate with BAS installer to adjust calibration coefficients. Report coefficients in air balance report.

4. Design condition test
   a. Test with system operating at design fan and minimum outside air flow conditions described above and report the following on a schematic of the system:
      1) Tags of all equipment
      2) Manufacturer and model of all fans and motors
      3) Motor horsepower, rpm, volts, phase, full load amps
      4) Sheave data at motor and fan; belt data
      5) Fan airflow rate at all locations measured, as listed above
      6) Final measured fan speed and amps
      7) Amps and kilowatts from variable speed drives
      8) Variable speed drive speed in hertz
      9) Static pressures measured at
         a) Return air plenum
         b) Downstream of return fan
         c) Mixed air plenum
         d) Downstream of filter
         e) Downstream of coil
         f) Discharge of supply fans
         g) At static pressure sensor
      10) Concurrent airflow rate readings from BAS airflow sensors as applicable
      11) Concurrent fan data
         a) Volts and amps
         b) Amps and kilowatts from variable speed drive
         c) Variable speed drive speed in hertz
         d) Entering and leaving fan static pressure
         e) Flow rate

C. AHU-2, AHU-3

1. Airflow Readings
   a. Total supply air quantities shall be determined at all of the following where applicable
      1) Pitot traverse in the supply duct downstream, positive pressure side of the fan
      2) Pitot traverse at coil or filter bank
      3) Totaling the readings of individual terminals as read through the BAS
   b. Total return air quantities shall be determined at all of the following where applicable

1) Pitot traverse in the return air duct entering air handler
c. Outside air quantities shall be determined by all of the following where applicable
1) Subtracting pitot traverses of supply and return ducts
2) Outdoor airflow sensor reading as read through the BAS

2. Adjust fan speed using manual adjustment of variable speed drive for testing only. Do not change or adjust sheaves.

3. Supply fan maximum DP setpoint
a. Establish maximum static pressure setpoint (Max_DSP) in conjunction with the BAS installer as follows. All adjustments made via the BAS, not field measurements except as noted.
b. Test Conditions
1) Set all boxes/air valves to operate at maximum airflow setpoints; allow controls to stabilize.
2) To account for diversity, shut off boxes, starting with boxes whose dampers are the most closed, as indicated by the BAS, and upstream of the DP sensor, until the airflow as indicated in BAS equals scheduled design airflow rate.
c. Procedure
1) Manually lower fan speed slowly while observing VAV box/air valve airflow rates downstream of the static pressure sensor. Stop lowering speed when one or more VAV box/air valve airflow rates drops 10 percent below maximum airflow rate setpoint.
2) Once flow condition in previous step is achieved, note the BAS system static pressure reading at the duct static pressure sensor.
a) This reading becomes the maximum static pressure setpoint.
b) Using pressure taps at differential pressure sensor and handheld digital pressure sensor, verify accuracy of BAS reading.
d. Convey to the BAS installer
1) Static pressure setpoints
2) Any discrepancy between BAS differential pressure reading and handheld measurement
e. Report
1) Static pressure setpoint
2) Tag of VAV boxes/air valves that dropped below design maximum airflow rate in tests above. These are the critical boxes, those requiring the largest static pressure.

4. Return fan
a. Test 1: 100% Outdoor Air
1) Test Conditions
a) Supply fan at design supply air rate per Paragraph 3.14C.3.b
b) Economizer in 100% outdoor air position
c) All doors and windows closed in area served by air handler
d) All exhaust fans on in area served by air handler
e) Relief damper fully open
2) Procedure
a) Measure building pressure using BAS sensor.

b) Manually adjust return fan speed at variable speed drive to achieve 0.05” building pressure.
1. Fan speed may exceed 60 Hz if necessary. Do not change or adjust sheaves.
c) At the above conditions
1. Measure fan inlet and outlet pressures.
2. Outlet pressure also shall be measured with BAS. This pressure is the return fan static pressure setpoint for Test 1.

b. Test 2: Design Minimum Outdoor Air
1) Test conditions: Per Paragraph 3.14C.5.a.
2) Procedure
a) Measure return airflow rate across return air damper and minimum outdoor air rate across minimum outdoor air damper
b) Manually adjust return fan speed at variable speed drive by 5Hz.
c) Repeat these two steps until return air rate drops below design return air rate by 5%, then increase return fan speed 5Hz.
d) At the above conditions
1. Measure fan inlet and outlet pressures.
2. Outlet pressure also shall be measured with BAS. This pressure is the return fan static pressure setpoint for Test 2.

c. Convey to the BAS installer
1) Return fan static pressure setpoints:
a) RFSPmin = Test 2 Outlet Pressure
b) RFSPmax = Larger of Test 1 and Test 2 Outlet Pressures
2) Return fan maximum speed if greater than 60 Hz.

d. Report
1) Amps and kilowatts from variable speed drive
2) Variable speed drive required speed in hertz
3) Inlet and outlet static pressure
4) Building static pressure

5. Outside air flow measuring station calibration
a. Test Conditions
1) Command all VAV boxes to design conditions per Paragraph 3.14C.3.b.
2) Override the economizer to 100% outdoor air, i.e. configure the outdoor air damper to be 100% open and the return air damper to be 0% open.
3) Start supply fan and run it slowly from 20% speed up to 100% speed, in 20% increments with a pause at each step to allow time for the VAV boxes to communicate. At each 20% increment, measure and report:
a) Sum of VAV box airflows as displayed on BAS AHU graphic
b) Airflow measurement station airflow reading
c) Traverse across supply air duct, filter bank, or other location where the most accurate airflow reading is possible

b. Plot the speed vs. all three measured airflows. They should be linear and the three readings should be within 10% of each other.
c. Coordinate with BAS installer to adjust calibration coefficients. Report coefficients in air balance report.

6. Design condition test

a. Test with system operating at design fan and minimum outside air flow conditions described above and report the following on a schematic of the system:
   1) Tags of all equipment
   2) Manufacturer and model of all fans and motors
   3) Motor horsepower, rpm, volts, phase, full load amps
   4) Sheave data at motor and fan; belt data
   5) Fan airflow rate at all locations measured, as listed above
   6) Final measured fan speed and amps
   7) Amps and kilowatts from variable speed drives
   8) Variable speed drive speed in hertz
   9) Static pressures measured at
      a) Return air plenum
      b) Downstream of return fan
      c) Mixed air plenum
      d) Downstream of filter
      e) Downstream of coil
      f) Discharge of supply fans
      g) At static pressure sensor
   10) Concurrent airflow rate readings from BAS airflow sensors, including sum of VAV box airflow rates
   11) Concurrent fan data
      a) Volts and amps
      b) Amps and kilowatts from variable speed drive
      c) Variable speed drive speed in hertz
      d) Entering and leaving fan static pressure
      e) Flow rate, summed from BAS terminals
      f) Fan airflow sensor reading from BAS (sum of VAV box airflow rates)

D. VAV boxes

1. Use default airflow calibration coefficients. No TAB required.

E. Laboratories

1. Supply and General Exhaust Air Valves. Use factory airflow calibration. No TAB required.

2. Fume Hoods
   a. Test only; balancing is dynamic via the controls
   b. Ensure airflow valves are fully operational and airflow setpoint to controller is set to scheduled design rates as scheduled herein.
   c. Adjust sash to and provide velocity readings for each of the following based on design open position, 18-inch:
      1) 100%
      2) 33%
   d. Test and report
      1) Velocity and airflow rate at hood face
      2) Traverse of exhaust duct to hood
      3) Concurrent feedback from exhaust air valves through BAS

e. If BAS feedback and measured airflow rates differ by more than 10%, direct the air valve supplier to make required corrections and recalibration. Do not adjust calibration without approval of air valve supplier.
f. ASHRAE 110 testing not required since it was recently completed when presence sensor was added.

3. Emergency Exit Tests
   a. Applies only to these labs:
      1) Room 235 (17 hood)
      2) Room 242 (5 hoods)
   b. Procedure:
      1) Simulate failure of supply air to the lab by fully shutting off all supply air valves.
      2) Test door opening force. If more than 15 pounds, gradually reduce minimum hood exhaust setpoints uniformly for all hoods until 15 pounds is reached.
   c. Report
      1) Initial door opening force at design hood exhaust rates
      2) Percent of design hood exhaust rates needed to reduce door opening force to 15 pounds
      3) Initials of BAS installer to indicate that percent hood multiplier was transmitted to them and included in control sequences

F. Chilled Water and Hot Water Distribution Systems

1. Coil Test & Balance, HW and CHW system
   a. System is self-balancing. Two-way control valves at coils prevent each coil from being over-supplied with water, other than minor excursions during transients such as cool-down or warm-up. Conventional balancing (throttling of balancing valves) will increase pump energy use by not allowing aggressive differential pressure setpoint reset. Hence, adjust all balancing valves on any coil or pump to be 100% open regardless of current balancing valve position.
   b. Report with all control and balancing valves 100% open to coil and pumps operating at full speed
      1) Coils with modulating two-way control valves
         a) Terminal tag
         b) Control valve model number and serial number
         c) Pressure drop across coil
         d) Flow as measured by calibrated balancing valve (where applicable).
         e) Balancing valve position (should be 100% open)
      2) Pumps
         a) Tag
         b) Manufacturer and model of pump and motor
         c) Motor horsepower, volts, phase, full load amps
         d) Pump shut-off head from curves, measured shut-off head, and resulting impeller diameter from pump curve
         e) At test condition specified
            1. Volts and amps
            2. Calculated brake horsepower
            3. Entering and leaving gage pressure and difference in feet

4. Flow rate deduced from pump curve
5. For pump with variable speed drive
   a. Speed (Hz)
   b. Kilowatts

f) Include pump curve from manufacturer's website.

2. Variable Speed Drive Setpoint Determination
   a. No TAB required. See Section 259000.

3.15 SYSTEM COMMISSIONING

A. Sequencing. The following list outlines the general sequence of events for submittals and commissioning:

1. Submit Submittal Package 0 (Qualifications) and receive approval.

2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.

3. Initiate installation of BAS hardware, devices and wiring.

4. Develop point database and application software.

5. Simulate sequencing and debug programming off-line to the extent practical.

6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.

7. Complete installation of BAS hardware, devices and wiring.

8. Install point database and application software in field panels.

9. Submit Submittal Package 3 (Pre-Functional Test Forms) and receive approval.

10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit completed forms as Submittal Package 4 (Pre-Functional Test Report) for approval.

11. Receive BAS Pre-functional Test Report approval and approval to schedule Functional Tests.

12. Field test application programs prior to functional testing.

13. Submit Package 5 (Post-Construction Trend Points List) in format specified for review and approval.

14. Receive approval of successful Trend Log configuration, or reconfigure as required.

15. Prepare and initiate commissioning Trend Logs.

16. Perform and record functional tests and submit Submittal Package 6 (Functional Test Report) for approval.

17. Submit Package 7 (Training Materials) and receive approval.

18. Receive BAS Functional Test Report approval and approval to schedule Demonstration Tests.

19. Perform Demonstration Tests to Commissioning Provider and College's Representatives and submit Demonstration Test Report.

20. Receive acceptance of Demonstration Tests.

21. Train College personnel on BAS operation and maintenance.

22. Substantial Completion

23. Submit Package 8 (Post-Construction Trend Logs) in format specified for review and approval.

24. Receive approval of successful Trend Log tests, or retest as required.

25. Complete all items in Completion Requirements per Paragraph 1.10B.

26. Provide administration level password access to the College.

27. Final Acceptance

28. Begin Warranty Period.

29. Prepare and initiate continuous Trend Logs per Paragraph 2.13A.4.

30. Update all software as specified.

31. End of Warranty Period

B. Pre-functional tests

1. General
   a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
   b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
   c. Verify integrity/safety of all electrical connections.
   d. Verify that shielded cables are grounded only at one end.
   e. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.

2. Test Documentation
   a. Prepare forms to document the proper startup of the BAS components.
   b. All equipment shall be included on test forms including but not limited to

1) Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.
2) Digital Outputs: Proper installation, normal position, response to command at CU
3) Digital Inputs: Proper installation, device test, response at CU
4) Analog Outputs: Proper installation of devices, verification of maximum and minimum stroke.
5) Analog Inputs: Proper installation of sensors, calibration
6) Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.
7) Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.
8) Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.
9) Network Traffic: Document speed of screen generation, alarm and signal propagation in system with all required commissioning trends active.

c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
d. Submit blank forms for approval in Submittal Package 3.
e. Complete work, document results on forms, and submit for approval as Submittal Package 4 (Pre-Functional Test Report).

3. Digital Outputs
   a. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

4. Digital Inputs
   a. Adjust setpoints, where applicable.
      1) For current switches used as status on fans, adjust current setpoint so that fan status is OFF when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
      2) For current switches used as status on pumps, adjust current setpoint so that pump status is OFF when pump is dead-headed (temporarily close discharge valve).
      3) For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).

5. Analog Outputs
   a. Verify start and span are correct and control action is correct.
   b. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
   c. Check all normal positions of fail-safe actuators.
   d. For outputs to reset other manufacturer's devices (for example, chiller setpoint) and for feedback from them, calibrate ranges to establish proper parameters.

6. Analog Input Calibration
   a. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
      1) Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
      2) Handheld: Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.10.
   b. The calibrating parameters in software (such as slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
   c. Inaccurate sensors must be replaced if calibration is not possible.

7. Alarms and Interlocks
   a. A log shall be kept and initialed by the technician indicating date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
   b. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   c. Test fire and life safety systems alarm contacts if and only if changes were made to FAS contacts and wiring.
   d. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   e. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

8. Variable Frequency Drive Minimum Speed
   a. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor losses to be minimal at low speeds.
   b. Determine minimum speed setpoint as follows:
      1) Start the fan or pump.
      2) Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences.
      3) Observe fan/pump in field to ensure it is visibly rotating.
         a) If not, gradually increase speed until it is.
      4) The speed at this point shall be the minimum speed setpoint for this piece of equipment.
      5) Record minimum speeds in log and store in software point as indicated in Guideline 36.

9. Tuning
   a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under

normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted)

Controlled Variable	Control Accuracy
Duct Pressure	±0.1 inches w.g.
Building and relief plenum	±0.01 inches w.g.
Airflow and water flow	±10%
Space Temperature	±1.5ºF
Condenser Water Temperature	±2ºF
Chilled Water Temperature	±1ºF
Duct Temperature	±2ºF
Water Differential Pressure	±1.5 psi
Others	±2 times reported accuracy

10. Interface and Control Panels
    a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
    b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
    c. Check power supplies for proper voltage ranges and loading.
    d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
    e. Check for adequate signal strength on communication networks.
    f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
    g. Ensure that buffered or volatile information is held through power outage.
    h. With all system and communications operating normally, sample and record update and annunciation times for critical alarms fed from the panel to the Operator Interface.
    i. Check for adequate grounding of all BAS panels and devices.

11. Operator Interfaces
    a. Verify that all elements on the graphics are functional and are properly bound to physical devices or virtual points, and that hot links or page jumps are functional and logical.
    b. Verify that the alarm logging, paging, emailing etc. are functional and per requirements.

C. Functional Tests

1. Test schedule shall be coordinated with the Commissioning Provider (Taylor Engineers) and College’s Representative.

2. Functional tests may be witnessed by College’s Representative at the College’s option.

3. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor's start-up technician.

4. Test documentation
   a. Commissioning Provider will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
   b. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc. and provide to Commissioning Provider.
   c. Complete work, document results on forms, and submit for approval as Submittal Package 6 Functional Test Report. Tutorials for using the functional test Excel workbook can be found here.

D. Demonstration Test

1. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Commissioning Provider. Tests will be designed to occur over no longer than 2 working days.

2. Schedule the demonstration with the Commissioning Provider and College's Representative at least 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.

3. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

4. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Provider will supply the test forms at the site at the start of the tests.

5. Demonstration tests may be witnessed by College's Representative at the College's option.

6. Contractor shall conduct tests as directed by and in the presence of the Commissioning Provider and complete test forms. Commissioning Provider will document the test results as the Demonstration Test Report after tests are complete.

7. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

E. Trend Log Tests

1. Trends shall be fully configured to record and store data to the server for the points and at the interval listed in Paragraph 2.12 as follows:
   a. Commissioning: Configure trends prior to functional testing phase. Retain configuration until post-construction commissioning trend review has been

completed successfully and accepted by the College's representative. Trends shall be deactivated after acceptance.

b. Continuous: After system acceptance, configure trends for the purpose of long term future diagnostics. Configure trends to overwrite the oldest trends at the longest interval possible without filling the server hard disk beyond 80%.

2. Post-Construction Trend Test
   a. Trend logging shall not commence until Demonstration Tests are successfully completed.
   b. Hardware Points. Contractor shall configure points to trend as indicated in the Commissioning Trend column listed in Paragraph 2.12 points.
   c. Software Points. Include the following in trends of systems and zones whose hardware points are being trended as called for above. Time interval shall be the same as associated hardware point.
      1) All setpoints and limits that are automatically reset, such as supply air temperature and fan static pressure setpoints, plus the points that are driving the reset, such as zone level cooling and static pressure requests
      2) All setpoints that are adjustable by occupants
      3) Outputs of all control loops, other than those driving a single AO point that is already being trended
      4) System mode points (e.g. Warm-up, Occupied, etc.)
      5) Global overrides such as demand shed signals
      6) Calculated performance monitoring points, such as chiller efficiency
   d. Submit for review and approval by the Commissioning Provider a table of points to be trended along with trend intervals or change-of-value a minimum of 14 days prior to trend collection period, as Submittal Package 5.
   e. Trends shall be uploaded to the CSS in data format specified in Paragraph 2.12C.3.
   f. Trend logs of all points indicated above shall be collected for a 3 week Trend Period.
   g. At the completion of the Trend Period, data shall be reviewed by the Contractor to ensure that the system is operating properly. If so, data shall be submitted to the College in an electronic format agreed to by the College and Contractor (such as flash drive or via direct access to the CSS via the internet) as Submittal Package 8.
   h. Data will be analyzed by the Commissioning Provider.
   i. The system shall be accepted only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps f to h above shall be repeated for the same Trend Period until there is a complete Trend Period of error free operation.
   j. After successfully completing the Post-Construction Trend Tests, the Contractor shall configure all points to trend as indicated in the Continuous Trend column listed in Paragraph 2.12 points list.

F. Remedial Work

1. Repair or replace defective Work, as directed by College's Representative in writing, at no additional cost to the College.

2. Restore or replace damaged Work due to tests as directed by College's Representative in writing, at no additional cost to the College.

3. Restore or replace damaged Work of others, due to tests, as directed by College's Representative in writing, at no additional cost to the College.

4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the College's Representative, at no additional cost to the College.

5. Contractor shall compensate College's Representatives and Commissioning Provider on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the College.

3.16 TRAINING

A. Coordinate schedule and materials with the College.

B. Interim Training

1. Provide minimal training so the operating staff can respond to occupant needs and other operating requirements during start-up and commissioning phase.

C. Formal Training

1. Training shall be conducted after all commissioning is complete and systems are fully operational.

2. Training materials, including slides, shall be submitted prior to any training in Submittal Package 7.

3. ALC Training
   a. It may be assumed that College building engineers have been previously trained on the existing ALC system.
   b. Include training on ALC system operations only for new features installed at CSS/OWS as a part of this project.

4. Jobsite Training
   a. Include 24 hours total of on-site training to assist personnel in becoming familiar with job-specific issues, systems, control sequences, etc.
   b. College shall be permitted to videotape training sessions.

5. Training may be in non-contiguous days at the request of the College.

6. During the warranty period, provide unlimited telephone support for all trained operators.

END OF SECTION 250000

ZONE GROUP SUMMARY

xx.x °F
xx %RH

Schedule

Zone Group Summary

Zone Group Name 1st Floor
Mode Occupied

AHU-x-x
SAT xx.x °F
DSP xx.x in.wg
Mode Occupied
Alarm OK

Heating Plant
HWST xxx °F
Status ON
Alarm OK

Chiller Plant
CHWST xxx °F
Status ON
Alarm OK

Mode Requests

Occupied	xxx
Warmup	xxx
Cooldown	xxx
Setback	xxx
Setup	xxx

System/Plant Requests

Cooling SAT Reset	xxx
Duct SP Reset	xxx
HW Plant	xxx
HWST Reset	xxx
Min OA CFM	xxx
Max CO2 DCV	xxx

Total Airflow

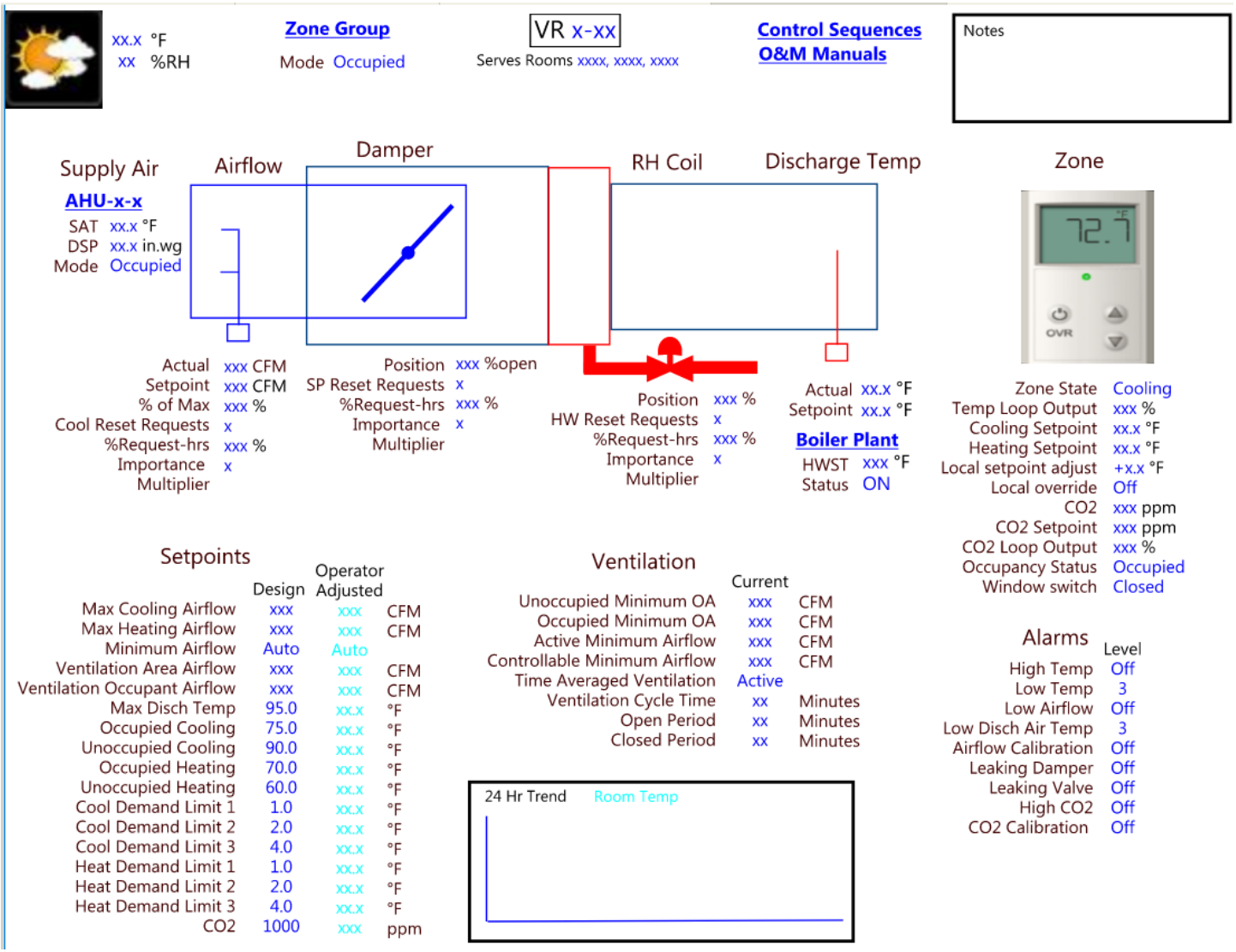
Airflow Setpoints	xxx	cfm
Actual Airflow	xxx	cfm
Occupant OA	xxx	cfm
Area OA	xxx	cfm
Total OA	xxx	cfm

Zone Alarms

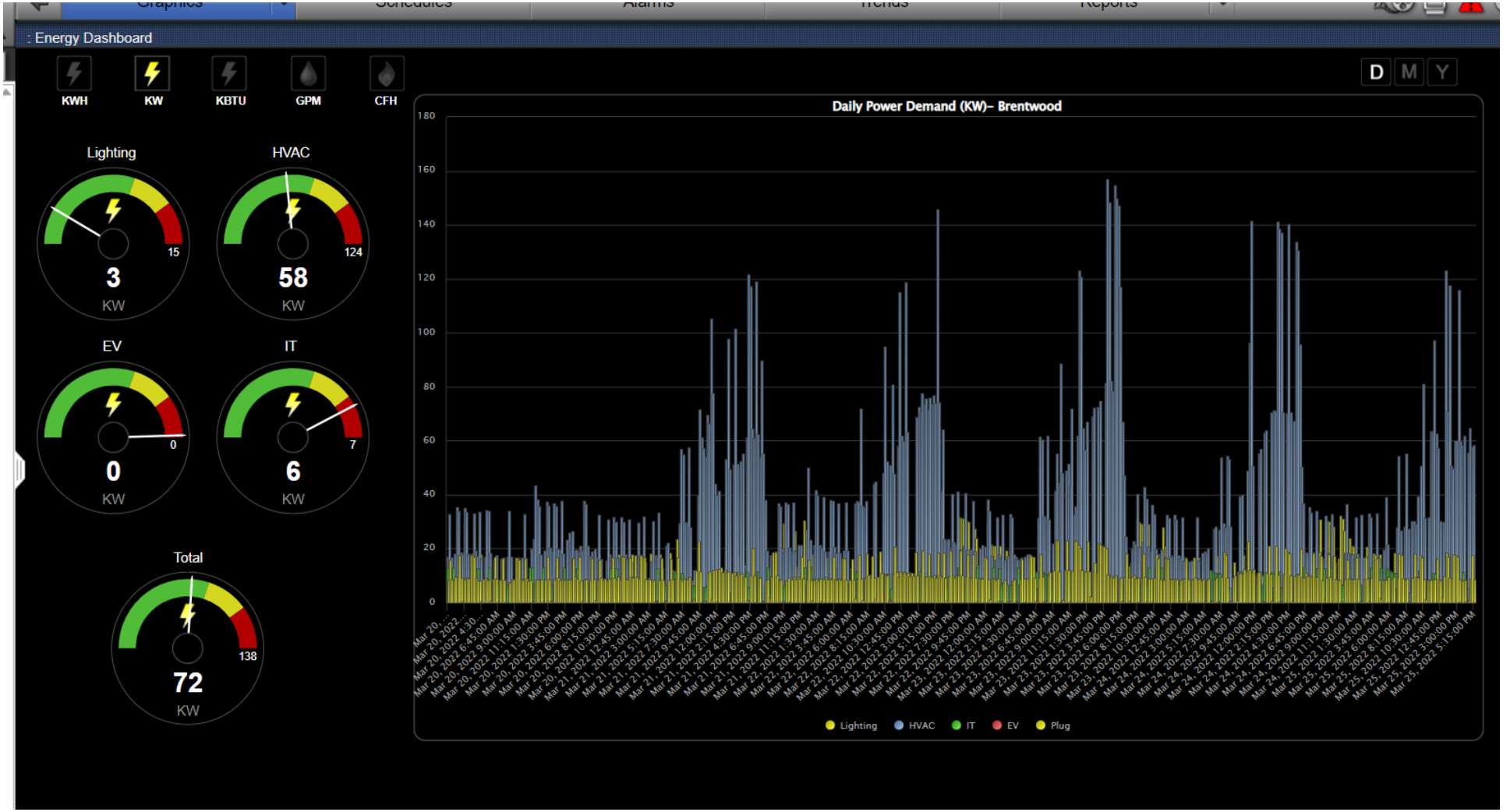
High Temp	xxx	Airflow Calibration	xxx
Low Temp	xxx	Leaking Damper	xxx
High CO2	xxx	Rogue SATSP	xxx
CO2 Calibration	xxx	Rogue DSPSP	xxx
Low Airflow	xxx	Rogue HWSTSP	xxx

Zone		Zone Temperature			Airflow			Discharge Air			CO2			Cool Reset Requests			Static Pressure Reset Requests			HWST Reset Requests		
Tag	State	Actual °F	Heat Setpoint °F	Cool Setpoint °F	Actual CFM	Setpoint CFM	Damper %open	Temp °F	Setpoint °F	HW Valve %open	Actual PPM	Setpoint PPM	Loop Output %	Requests	%-Req-hrs	Importance Multiplier	Requests	%-Req-hrs	Importance Multiplier	Requests	%-Req-hrs	Importance Multiplier
VR 2012	Heating	70	70	75	200	220	15	93	95	90	500	1000	0	0	21	1	0	14	1	1	30	1
VC-2013	Cooling	75	70	75	200	220	15							0	21	1	0	14	1			

VAV REHEAT ZONE



ENERGY DASHBOARD



SECTION 259000

BUILDING AUTOMATION SEQUENCES OF OPERATION

PART 1 GENERAL

1.1 SUMMARY

A. Program and commission the Building Automation System (BAS) to execute the Sequences of Operation specified herein.

B. See Section 250000 Building Automation Systems for general requirements.

C. These control sequences include references to ASHRAE Guideline 36 and approved addenda. Where sequences are verbatim from Guideline 36, they are shown in green text. Not all informative text has been included. Sequences have been customized to include only Title 24 options where they take precedence over ASHRAE 90.1 and 62.1 requirements.

D. Guideline 36 sequences shall be programmed to exactly match the specified sequences verbatim. The Contractor may use “equivalent” alternative sequences only with formal approval by the Engineer. Proposed changes in sequences shall be clearly identified and included as a part of Submittal Package 2.

E. This file shall be maintained by the Contractor to include all approved changes to sequences made during testing and commissioning and shall become the final as-built sequences of operation installed on the CSS per Section 250000 Building Automation Systems.

1.2 INFORMATION PROVIDED BY DESIGNER

A. See equipment schedules on drawings for all setpoints unless otherwise noted below.

B. General Zone Information

1. Zone Temperature Setpoints
   a. Default setpoints shall be based on zone type as shown in Table 3.1.1.1.

Table 3.1.1.1 Default Setpoints

	Occupied		Unoccupied	
Zone Type	Heating	Cooling	Heating	Cooling
General (unless listed below)	70ºF	75ºF	60ºF	80ºF
Laboratory spaces	70ºF	75ºF	60ºF	80ºF
IDF/MDF	–	78ºF	–	78ºF

Elevator machine rooms	–	85ºF	–	85ºF

2. Outdoor Air Ventilation Setpoints
   a. All zone minimum outdoor air setpoints are scheduled in Points List.
      1) Vocc-min. Zone minimum outdoor airflow for occupants.
      2) Varea-min. Zone minimum outdoor airflow for building area.
      3) Indicate where occupied-standby mode is allowed based on the zone occupancy category.

3. CO2 Setpoints
   a. The CO2 setpoint for all occupancy types is 1000 ppm.

C. VAV Box Design Information

1. All VAV box setpoints are scheduled in Points List except as indicated below.

2. VAV Reheat Terminal Unit
   a. Zone maximum cooling airflow setpoint (Vcool-max)
   b. Zone minimum airflow setpoint (Vmin. This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.
   c. Zone maximum heating airflow setpoint (Vheat-max)
   d. Zone maximum DAT above heating setpoint (MaxΔT) = 25ºF
   e. The heating minimum airflow setpoint (Vheat-min) = 0

D. Lab Zone Design Information

1. All Lab Zone setpoints are scheduled in Points List except as indicated below.

2. Pressurization offset (Voffset).

3. Supply air valve(s). For pressure zones with multiple supply air valves, the first listed supply air valve controller is the master and setpoint adjustments (e.g. Vmin*) only apply to that zone. The other zones respond to temperature controls only. Total supply air is the sum of all supply air rates.
   a. Maximum airflow setpoint (Vmax)
   b. Minimum occupied airflow setpoint (Vmin-occ)
   c. Minimum unoccupied airflow setpoint (Vmin-unocc)
   d. Maximum heating airflow setpoint (Vheat-max) = Vcool-max
   e. Maximum cooling airflow setpoint (Vcool-max)
   f. Design heating coil leaving air temperature (SATmax) = scheduled coil LAT from original design drawings

4. Hood exhaust air valve
   a. Hood exhaust is controlled by on-board controllers with sash sensors and fume hood monitors, where specified. None of the control logic resides in the BAS, other than monitoring alarms and commissioning overrides.
   b. The following setpoints must be configured in the exhaust air valve controller.
      1) Maximum airflow setpoint (Vhex-max)

2) Maximum airflow setpoint with presence sensor indicating unoccupied (Vhex-max-unocc) = 60% of Vhex-max
3) Minimum airflow setpoint (Vhex-min)

5. General exhaust (GEX) air valve
   a. Maximum airflow setpoint (Vgex-max)

6. Other exhaust airflows, e.g. canopy/cabinet/snorkel etc. if applicable, see plans for quantity and airflow rates (Vother)

E. Zone Group Assignments

1. Unless otherwise specified by Owner, the following Zone Groups shall be created:

Zone Group Name	AH Tag	Terminal Unit Tags	Miscellaneous Equipment Tags	Default Schedule
Tiered assembly 136	AC-1	–	–	WD: 8 am to 8pm WE: off HOL: off
1st Floor Exhausted Classrooms	AH-2	VAV-2.3, 2.4, 2.10, 2.13, 2.14, 2.15, 2.16	EF-4	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Biology Classroom 132	AH-2	VAV-2.5		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Biology Classroom 131	AH-2	VAV-2.6		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Biology Classroom 129	AH-2	VAV-2.7		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Biology Lab 130	AH-2	SUP-2.8	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Biology Prep 128	AH-2	SUP-2.12	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off

1st Floor Biology Lab 126	AH-2	SUP-2.11	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Microbiology Lab 127	AH-2	SUP-2.9	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor corridor zones on AH-2	AH-2	VAV-2.1, 2.2		Occupied when any other 1st floor AHU-2 Zone Group is occupied
1st Floor Offices	AH-3	VAV-3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14	EF-5	WD: 6 am to 8 pm WE: off HOL: off
1st Floor Biology Classroom 102	AH-3	VAV-3.6		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor Tutorial Center 103	AH-3	VAV-3.2, 3.3, 3.4, 3.5		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
1st Floor corridor zones on AH-3	AH-3	VAV-3.1		Occupied when any other 1st floor AHU-3 Zone Group is occupied
2nd Floor Chemistry Lab 237	AH-2	SUP-2.21, VAV 2.20	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Chemistry Lab 242	AH-2	SUP-2.27, VAV 2.28	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Chemistry Lab 235	AH-2	SUP-2.22A to D	EF-1, 2, 3	WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Strength Lab 230	AH-2	VAV2.29		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off

2nd Floor Physical Science 228	AH-2	VAV2.30, 2.31		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Physical Science 229	AH-2	VAV2.24		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Physical Science 227	AH-2	VAV2.25		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Physics Lab 226	AH-2	VAV2.33, 2.32		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor Tiered Classroom 225	AH-2	VAV2.26		WD: 7 am to 7 pm SAT: 7 am to 7 pm SUN: off HOL: off
2nd Floor corridor and office zones on AH-2	AH-2	VAV-2.17, 2.18, 2.19, 2.23		Occupied when any other 2nd floor AHU-2 Zone Group is occupied
2nd Floor Offices	AH-3	VAV-3.21, 3.22, 3.24, 3.25, 3.26, 3.27 3.28, 3.29, 3.31	EF-5	WD: 6 am to 8 pm WE: off HOL: off
2nd Floor Tech Media	AH-3	VAV-3.16, 3.17, 3.18, 3.19, 3.20		
2nd Floor corridor zones on AH-3	AH-3	VAV-3.15, 3.23		Occupied when any other 2nd floor AHU-3 Zone Group is occupied

F. Multiple-Zone VAV Air-Handler Design Information, AH-2, AH-3

1. Temperature Setpoints
   a. Min_ClgSAT, lowest cooling supply air temperature setpoint = scheduled cooling coil leaving air temperature plus 3°F
   b. Max_ClgSAT, highest cooling supply air temperature setpoint = 65°F
   c. OAT_Min, the lower value of the OAT reset range = 55°F
   d. OAT_Max, the higher value of the OAT reset range = 70°F

2. Ventilation Setpoints
   a. All AHU outdoor airflow setpoints are scheduled on Drawings.

1) AbsMinOA, the design outdoor air rate when all zones with CO2 sensors or occupancy sensors are unpopulated
   a) AH-2 = DesMinOA
   b) AH-3: 2310
2) DesMinOA, the design minimum outdoor airflow with areas served by the system are occupied at their design population, including diversity where applicable
   a) AH-2 = 38510
   b) AH-3: 5030

3. Economizer High Limit
   a. California Title 24 economizer high limit
      1) California climate zone = 12
      2) High limit option:
         a) Fixed dry bulb + differential dry bulb

4. Pressure Zone Group Assignments
   a. Currently the two AHU RFs are controlled independently. But during Cx, we may find coupling between the two pressure zones since they are open to each other on each floor. If so, combine the pressure zones and treat the entire building as one zone with pressure sensors averaged.

Pressure Zone Group Name	AHU Tag	RF Tag	Building Pressure Sensor Location(s)
AH-2 Pressure Zone	AH-2	RF-2	Existing
AH-3 Pressure Zone	AH-3	RF-3	Existing

G. Single-Zone VAV Air-Handler Design Information, AC-1

1. Temperature Setpoints
   a. Cool_SAT, lowest cooling supply air temperature setpoint = 55°F
   b. Heat_SAT, highest heating supply air temperature setpoint = 85°F
   c. MaxDPT, maximum supply air dew-point temperature = 75°F

2. Ventilation Setpoints
   a. For projects complying with the California Title 24 Ventilation Standards:
      1) MinOA, the design outdoor air rate when the zone with a CO2 sensor served by the system is unpopulated. MinOA shall equal Varea-min.
         a) AC-1: 335
      2) DesOA, the design minimum outdoor airflow with areas served by the system are occupied at their design population, including diversity where applicable
         a) AC-1: 2400

3. Economizer High Limit
   a. California Title 24 economizer high limit
      1) California climate zone = 12
      2) High limit option:
         a) Fixed dry bulb + differential dry bulb

H. Chilled Water Plant

1. Temperature Setpoints
   a. CHWSTmin, the lowest chilled water supply temperature setpoint for Chiller 1 = 44°F
   b. CHWSTmax, the maximum chilled water supply temperature setpoint used in plant reset logic = 60°F
   c. CWRTdes, the condenser water return (chiller condenser leaving) temperature at chiller selection conditions for Chiller X = 90°F
   d. CWSTdes, the condenser water supply (chiller condenser entering) temperature at chiller selection conditions for Chiller X= 80°F
   e. CH-LOT, the outdoor air lockout temperature below which the chiller plant is prevented from operating = 60°F

2. Differential Pressure Setpoints
   a. CHW-DPmin, the minimum differential pressure setpoint used in plant reset logic = 5 psi

3. Chiller Flow Setpoints
   a. CHW-MinFlow, the minimum chiller chilled water flowrate per manufacturer's recommendations for Chiller 1, in gpm = 200 gpm
   b. CHW-DesFlow, the design chiller chilled water flowrate for Chiller 1, in gpm = 580 gpm

4. Chiller Lift Setpoints
   a. LIFTminX, the minimum allowable lift at minimum load for Chiller X, as determined from the manufacturer's recommendations, where lift is the difference between condenser water return temperature and chilled water supply temperature.
      1) CH-1: 11°F
   b. LIFTmax, design lift at design load for Chiller X = 46°F

1.3 INFORMATION PROVIDED BY (OR IN CONJUNCTION WITH) THE TESTING, ADJUSTING, AND BALANCING CONTRACTOR

A. Coordinate with Testing, Adjusting and Balancing paragraph of Section 250000 for setpoint determination.

B. Multiple-Zone Air-Handler Information, AH-2, AH-3

1. Duct Design Maximum Static Pressure, Max_DSP

2. Minimum Fan Speed
   a. Minimum speed setpoints for all VFD-driven equipment shall be determined in accordance with Section 250000 Building Automation System specifications for the following, as applicable:
      1) Supply fan
      2) Return fan

3. Return-Fan Discharge Static Pressure Setpoints. (For return-fan direct building pressure control, see Section 3.8E.)

a. RFDSPmin. That required to deliver the design return air volume across the return air damper when the supply air fan is at design airflow and on minimum outdoor air. This setpoint shall be no less than 2.4 Pa (0.01 in. of water) to ensure outdoor air is not drawn backwards through the relief damper.
b. RFDSPmax. That required to exhaust enough air to maintain building static pressure at setpoint 12 Pa (0.05 in. of water) when the supply air fan is at design airflow and on 100% outdoor air.

C. Single-Zone Air-Handler Information, AC-1

1. Fan Speed Setpoints
   a. MinSpeed = 50% of MaxCoolSpeed
   b. MaxHeatSpeed = 50% of MaxCoolSpeed
   c. MaxCoolSpeed = current maximum speed

D. Chilled Water Plant

1. CHW-DPmax = 15 psi

2. LocalCHW-DPmax = 25 psi

3. Minimum Speeds
   a. Where minimum speeds are not required for flow control per other balancer provided setpoints above, minimum speed setpoints for all VFD-driven pumps and tower fans shall be determined in accordance with Section 250000 Building Automation System for the following as applicable:
      1) Cooling Tower Fan
      2) Chilled Water Pump

1.4 INFORMATION DETERMINED BY CONTROL CONTRACTOR

A. VAV Box Controllable Minimum

1. This section is used to determine the lowest possible VAV box airflow setpoint (other than zero) allowed by the controls (Vm) used in VAV box control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface.

2. The minimum setpoint *Vm* shall be determined from the table below for the VAV box manufacturer from approved submittals:

Inlet	Titus	Krueger	Price	MetalAire High Gain	ETI
4	15	15	20	15	15
6	30	35	30	30	30
8	55	60	55	50	55
10	90	90	95	85	90
12	120	130	135	110	130
14	190	175	195	155	180
16	245	230	260	210	235

Inlet	Titus	Krueger	Price	MetalAire High Gain	ETI
24x16	455	445	490	N/A	415

B. Lab Air Valve Controllable Minimum

1. This section is used to determine the lowest possible valve airflow setpoint allowed by the controls used in lab control sequences. The minimums shall be stored as software points that may be adjusted by the user but need not be adjustable via the graphical user interface. If not listed, obtain data from manufacturer with review and approval by Engineer.

2. The valve controllable minimum shall be determined from the table:

Inlet	AccuValve
8	80
10	120
12	180
14	250
12x18	260
12x24	350
12x36	520
12x48	700

PART 2 PRODUCTS

2.1 NOT USED

PART 3 EXECUTION

3.1 GENERAL

A. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be clearly identified and included as a part of Submittal Package 2.

B. Include costs for minor program modifications if required to provide proper performance of the system.

C. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup.

D. When a control loop is enabled or reenabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value.

E. A control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

F. When there are multiple outdoor air temperature sensors, the system shall use the valid sensor that most accurately represents the outdoor air conditions at the equipment being controlled.

   1. Outdoor air temperature sensors at air-handler outdoor air intakes shall be considered valid only when the supply fan is proven on and the unit is in Occupied Mode or in any other mode with the economizer enabled.

   2. The outdoor air temperature used for optimum start, plant lockout, and other global sequences shall be the average of all valid sensor readings. If there are four or more valid outdoor air temperature sensors, discard the highest and lowest temperature readings.

G. The term “proven” (i.e., “proven on”/“proven off”) shall mean that the equipment’s DI status point (where provided, e.g., current switch, DP switch, or VFD status) matches the state set by the equipment’s DO command point.

H. The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

I. The term “control loop” or “loop” is used generically for all control loops. These will typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the guidelines in the following subsections shall be followed.

   1. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.).

   2. Do not use the derivative term on any loops unless field tuning is not possible without it.

J. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

K. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

L. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point, and the software point shall be used in all sequences. Exceptions shall be made for machine or life safety.

M. Alarms

   1. There shall be 4 levels of alarm

a. Level 1: Life-safety message
b. Level 2: Critical equipment message
c. Level 3: Urgent message
d. Level 4: Normal message

2. Maintenance Mode. Operators shall have the ability to put any device (e.g., AHU) in/out of maintenance mode.
   a. All alarms associated with a device in maintenance mode will be suppressed. Exception: Life safety alarms shall not be suppressed.
   b. If a device is in maintenance mode, issue a daily Level 3 alarm at a scheduled time indicating that the device is still in maintenance mode.

3. Exit Hysteresis
   a. Each alarm shall have an adjustable time-based hysteresis (default: 5 seconds) to exit the alarm. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
   b. Each analog alarm shall have an adjustable percent-of-limit-based hysteresis (default: 0% of the alarm threshold, i.e., no hysteresis; alarm exits at the same value as the alarm threshold) the alarmed variable required to exit the alarm. Alarm conditions have ceased when the alarmed variable is below the triggering threshold by the amount of the hysteresis.

4. Latching. A latching alarm requires acknowledgment from the operators before it can return to normal, even if the exit deadband has been met. A nonlatching alarm does not require acknowledgment. Default latching status is as follows:
   a. Level 1 alarms: latching
   b. Level 2 alarms: latching
   c. Level 3 alarms: nonlatching
   d. Level 4 alarms: nonlatching

5. Post-exit Suppression Period. To limit alarms, any alarm may have an adjustable suppression period such that once the alarm is exited, its post-exit suppression timer is triggered and the alarm may not trigger again until the post-exit suppression timer has expired. Default suppression periods are as follows:
   a. Level 1 alarms: 0 minutes
   b. Level 2 alarms: 5 minutes
   c. Level 3 alarms: 24 hours
   d. Level 4 alarms: 7 days

N. VFD Speed Points

To avoid operator confusion, the speed command point (and speed feedback point, if used) for VFDs should be configured so that a speed of 0% corresponds to 0 Hz, and 100% corresponds to maximum speed set in the VFD, not necessarily 60 Hz. The maximum speed may be limited below 60 Hz to protect equipment, or it may be above 60 Hz for direct drive equipment. Drives are often configured such that a 0% speed signal corresponds to the minimum speed programmed into the VFD, but that causes the speed AO value and the actual speed to deviate from one another.

1. The speed AO sent to VFDs shall be configured such that 0% speed corresponds to 0 Hz, and 100% speed corresponds to maximum speed configured in the VFD.

It is desirable that the minimum speed reside in the VFD to avoid problems when the VFD is manually controlled at the drive. But minimums can also be adjusted inadvertently in the VFD to a setpoint that is not equal to the minimum used in software. The following prevents separate, potentially conflicting minimum speed setpoints from existing in the BAS software and the drive firmware.

2. For each piece of equipment, the minimum speed shall be stored in a single software point; in the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BAS. See Section 1.3 for minimum speed setpoints. The active minimum speed parameter shall be read every 60 minutes via the drive's network interface. When a mismatch between the drive's active minimum speed and the minimum speed stored in the software point is detected, the minimum speed stored in the software point shall be written to the VFD via the network interface to restore the active minimum speed parameter to its default value, and generate a Level 4 alarm.

The minimum speed parameter is read via the network interface to detect any changes in the minimum speed parameter. Upon detecting a change in the minimum speed setting, the correct minimum speed stored in a BAS software point is written back to the drive via the network interface to override any changes that are made locally to the minimum speed parameter at the VFD.

O. Trim & Respond Set-Point Reset Logic

1. T&R set-point reset logic and zone/system reset requests, where referenced in sequences, shall be implemented as described below.

2. A "request" is a call to reset a static pressure or temperature setpoint generated by downstream zones or air-handling systems. These requests are sent upstream to the plant or system that serves the zone or air handler that generated the request.
   a. For each downstream zone or system, and for each type of set-point reset request listed for the zone/system, provide the following software points:
      1) Importance-Multiplier (default = 1)

Importance-Multiplier is used to scale the number of requests the zone/system is generating. A value of zero causes the requests from that zone or system to be ignored. A value greater than one can be used to effectively increase the number of requests from the zone/system based on the critical nature of the spaces served.

      2) Request-Hours Accumulator. Provided SystemOK (see Section 3.1R) is true for the zone/system, every x minutes (default 5 minutes), add x divided by 60 times the current number of requests to this request-hours accumulator point.
      3) System Run-Hours Total. This is the number of hours the zone/system has been operating in any mode other than Unoccupied Mode.

Request-Hours accumulates the integral of requests (prior to adjustment of Importance-Multiplier) to help identify zones/systems that are driving the reset logic. Rogue zone identification is particularly critical in this context, because a single rogue zone can keep the T&R loop at maximum and prevent it from saving any energy.

4) Cumulative%-Request-Hours. This is the zone/system Request-Hours divided by the zone/system run-hours (the hours in any mode other than Unoccupied Mode) since the last reset, expressed as a percentage.
5) The Request-Hours Accumulator and System Run-Hours Total are reset to zero as follows:
   a) Reset automatically for an individual zone/system when the System Run-Hours Total exceeds 400 hours.
   b) Reset manually by a global operator command. This command will simultaneously reset the Request-Hours point for all zones served by the system.
6) A Level 4 alarm is generated if the zone Importance-Multiplier is greater than zero, the zone/system Cumulative% Request Hours exceeds 70%, and the total number of zone/system run hours exceeds 40.

b. See zone and air-handling system control sequences for logic to generate requests.
c. Multiply the number of requests determined from zone/system logic times the Importance-Multiplier and send to the system/plant that serves the zone/system. See system/plant logic to see how requests are used in T&R logic.

3. For each upstream system or plant setpoint being controlled by a T&R loop, define the following variables. Initial values are defined in system/plant sequences below. Values for trim, respond, time step, etc. shall be tuned to provide stable control. See Table 5.1.14.3.

Table 5.1.14.3 Trim & Respond Variables

Variable	Definition
Device	Associated device (e.g., fan, pump)
SP0	Initial setpoint
SPmin	Minimum setpoint
SPmax	Maximum setpoint
Td	Delay timer
T	Time step
I	Number of ignored requests
R	Number of requests from zones/systems
SPtrim	Trim amount
SPres	Respond amount (must be opposite in sign to SPtrim)
SPres-max	Maximum response per time interval (must be same sign as SPres)

Informative Note: The number of ignored requests (I) should be set to zero for critical zones or air handlers.

4. Trim & Respond logic shall reset the setpoint within the range SPmin to SPmax. When the associated device is off, the setpoint shall be SP0. The reset logic shall be active while the associated device is proven on, starting Td after initial device start command. When active, every time step T, if R≤I, trim the setpoint by SPtrim. If there are more than I requests, respond by changing the setpoint by SPres*(R – I), (i.e., the number of requests minus the number of ignored requests) but no more than SPres-max. In other words, every time step T.

If R≤I, change Setpoint by SPtrim
If R > I, change setpoint by (R – I)*SPres but no larger than SPres-max

P. Equipment Staging and Rotation

1. Not used.

Q. Air Economizer High Limits

1. Economizer shall be disabled whenever the outdoor air conditions exceed the economizer high-limit setpoint as specified. Setpoints shall be automatically determined by the control sequences (to ensure they are correct and meet code) based on energy standard, climate zone, and economizer high-limit-control device type selected by the design engineer in Section 1.2F.2.a.2)a) or 1.2G.2. Setpoints listed below are for current California Energy Standards.

2. Title 24-2019

Device Type	California Climate Zones	Required High Limit (Economizer off when)
Fixed dry bulb	1, 3, 5, 11 to 16	TOA > 24°C (75°F)
	2, 4, 10	TOA > 23°C (73°F)
	6, 8, 9	TOA > 22°C (71°F)
	7	TOA > 21°C (69°F)
Differential dry bulb	1, 3, 5, 11 to 16	TOA > TRA
	2, 4, 10	TOA > TRA – 1°C (2°F)
	6, 8, 9	TOA > TRA –2°C (4°F)
	7	TOA > TRA – 3°C (6°F)
Fixed enthalpy + fixed dry bulb	All	hOA > 66 kJ/kg (28 Btu/lb) or TOA > 24°C (75°F)

R. Hierarchical Alarm Suppression

1. For each piece of equipment or space controlled by the BAS, define its relationship (if any) to other equipment in terms of “source,” “load,” or “system.”

a. A component is a “source” if it provides resources to a downstream component, such as a chiller providing chilled water (CHW) to an AHU.
b. A component is a “load” if it receives resources from an upstream component, such as an AHU that receives CHW from a chiller.
c. The same component may be both a load (receiving resources from an upstream source) and a source (providing resources to a downstream load).
d. A set of components is a “system” if they share a load in common (i.e., collectively act as a source to downstream equipment, such as a set of chillers in a lead/lag relationship serving air handlers).
    1) If a single component acts as a source for downstream loads (e.g., an AHU as a source for its VAV boxes), then that single-source component shall be defined as a “system” of one element.
    2) For equipment with associated pumps (chillers, boilers, cooling towers):
        a) If the pumps are in a one-to-one relationship with equipment they serve, the pumps shall be treated as part of the system to which they are associated (i.e., they are not considered loads), as a pump failure will necessarily disable its associated equipment.
        b) If the pumps are headered to the equipment they serve, then the pumps may be treated as a system, which is a load relative to the upstream equipment (e.g., chillers) and a source relative to downstream equipment (e.g., air handlers).

2. For each system as defined in Section 3.1R.1.d, there shall be a SystemOK flag, which is either true or false.

3. SystemOK shall be true when all of the following are true:
    a. The system is proven on.
    b. The system is achieving its temperature and/or pressure setpoint(s) for at least 5 minutes
    c. The system is ready and able to serve its load

4. SystemOK shall be false while the system is starting up (i.e., before reaching setpoint) or when enough of the system’s components are unavailable (in alarm, disabled, or turned off) to disrupt the ability of the system to serve its load. This threshold shall be defined by the design engineer for each system.
    a. By default, Level 1 through Level 3 component alarms (indicating equipment failure) shall inhibit SystemOK. Level 4 component alarms (maintenance and energy efficiency alarms) shall not affect SystemOK.
    b. The operator shall have the ability to individually determine which component alarms may or may not inhibit SystemOK.

5. The BAS shall selectively suppress (i.e., fail to announce; alarms may still be logged to a database) alarms for load components if SystemOK is false for the source system that serves that load.
    a. If SystemOK is false for a cooling water system (i.e., chiller, cooling tower, or associated pump), then only high-temperature alarms from the loads shall be suppressed.
    b. If SystemOK is false for a heating water system (i.e., boiler or associated pump), then only low temperature alarms from the loads shall be suppressed.
    c. If SystemOK is false for an air-side system (air handler, fan coil, VAV box, etc.), then all alarms from the loads shall be suppressed.

6. This hierarchical suppression shall cascade through multiple levels of load-source relationship such that alarms at downstream loads shall also be suppressed.

7. The following types of alarms will never be suppressed by this logic:
   a. Life/safety and Level 1 alarms
   b. Failure-to-start alarms (i.e., equipment is commanded on, but status point shows equipment to be off)
   c. Failure-to-stop/hand alarms (i.e., equipment is commanded off, but status point shows equipment to be on)

S. Time-Based Suppression

1. Calculate a time-delay period after any change in setpoint based on the difference between the controlled variable (e.g., zone temperature) at the time of the change and the new setpoint. The default time delay period shall be as follows:
   a. For thermal zone temperature alarms: 18 minutes per °C (10 minutes per °F) of difference but no longer than 120 minutes
   b. For thermal zone temperature cooling requests: 9 minutes per °C (5 minutes per °F) of difference but no longer than 30 minutes
   c. For thermal zone temperature heating requests: 9 minutes per °C (5 minutes per °F) of difference but no longer than 30 minutes

T. Occupancy Sensor Status

1. Occupancy status of lab spaces shall be via relays energized by a light fixture in the lab that is controlled by the existing lighting control occupancy sensor.

2. All other zones shall be assumed to be “populated” (the Guideline 36 term) based on Occupied Mode schedule. Occupancy sensors will not be used at this time, but programming for occupancy sensors shall remain enabled for future integration with a future smart lighting control system.

U. Pandemic Mode

1. Provide a software switch on the Home Page graphic for Pandemic Mode on/off. The switch shall include a timer that can be manually set by the operator for a period of up to 60 weeks, after which the Mode shall be shut off and control logic and setpoints returned to normal.

2. When the Pandemic Mode timer is on:
   a. All CO2 DCV setpoints shall be set to 800 ppm.
   b. Occupancy sensors used for Occupied Standby logic shall be not reset zone ventilation rates; with respect to ventilation, the zone shall be considered “populated”.
   c. All Zone Group time schedules shall indicate Occupied Mode one hour prior to the scheduled time. This earlier time shall be reflected in optimum start logic.

V. Wildfire Mode

1. Provide a 2-position software switch on the Home Page graphic for Wildfire Mode:
   a. Off. Locks Wildfire Mode off.
   b. On. Turns Wildfire Mode on for a preset period of time, after which the Mode shall be shut off. The preset time shall be operator adjustable for up to 4 weeks.

2. When the Wildfire Mode timer is on:
   a. Disable all economizers (lock High Limit to off).

3.2 GENERIC VENTILATION ZONES

A. Zone Minimum Outdoor Air and Minimum Airflow Setpoints

1. For every zone that requires mechanical ventilation, the zone minimum outdoor airflows and setpoints shall be calculated depending on the governing standard or code for outdoor air requirements.

2. See Section 1.2C for zone minimum airflow setpoint Vmin.

3. For compliance with California Title 24, outdoor air setpoints shall be calculated as follows:
   a. See Section 1.2B.2 for zone ventilation setpoints.
   b. Determine the zone minimum outdoor air setpoints Zone-Abs-OA-min and Zone-Des-OA-min.

Zone-Abs-OA-min is used in terminal-unit sequences and air-handler sequences. Zone-Des-OA-min is used in air-handler sequences only.

      1) Zone-Abs-OA-min shall be reset based on the following conditions in order from highest to lowest priority:
         a) Zero if the zone has a window switch and the window is open.
         b) Zero if the zone has an occupancy sensor and is unpopulated and is permitted to be in occupied-standby mode per Section 1.2B.2.a.3).
         c) Varea-min if the zone has a CO2 sensor.
         d) Zone-Des-OA-min otherwise.
      2) Zone-Des-OA-min is equal to the following, in order from highest to lowest priority:
         a) Zero if the zone has a window switch and the window is open.
         b) Zero if the zone has an occupancy sensor, is unpopulated, and is permitted to be in occupied-standby mode per Section 1.2B.2.a.3).
         c) The larger of Varea-min and Vocc-min otherwise.
   c. Vmin
      1) Shall be equal to Zone-Abs-OA-min if Vmin in Section 1.2C is “AUTO”;
      2) Else shall be equal to Vmin as entered in Section 1.2C.
   d. The occupied minimum airflow Vmin* shall be equal to Vmin except as noted below, in order from highest to lowest priority:
      1) If the zone has an occupancy sensor and is permitted to be in occupied-standby mode per Section 1.2B.2.a.3), Vmin* shall be equal to zero when the room is unpopulated.
      2) If the zone has a window switch, Vmin* shall be zero when the window is open.

3) If the zone has a CO2 sensor:
   a) See Section 1.2B.2.a.3) for CO2 setpoints.
   b) During Occupied Mode, a P-only loop shall maintain CO2 concentration at setpoint; reset from 0% at setpoint minus 200 PPM and to 100% at setpoint.
   c) Loop is disabled and output set to zero when the zone is not in Occupied Mode.
   d) For cooling-only VAV terminal units, reheat VAV terminal units, constant-volume series fan-powered terminal units, dual-duct VAV terminal units with mixing control and inlet airflow sensors, dual-duct VAV terminal units with mixing control and a discharge airflow sensor, or dual-duct VAV terminal units with cold-duct minimum control:
      1. The CO2 control loop output shall reset the occupied minimum airflow setpoint Vmin* from the zone minimum airflow setpoint Vmin at 0% up to maximum cooling airflow setpoint Vcool-max at 50%, as shown in Figure 5.2.1.4-1. The loop output from 50% to 100% will be used at the system level to reset outdoor air minimum; see AHU controls.

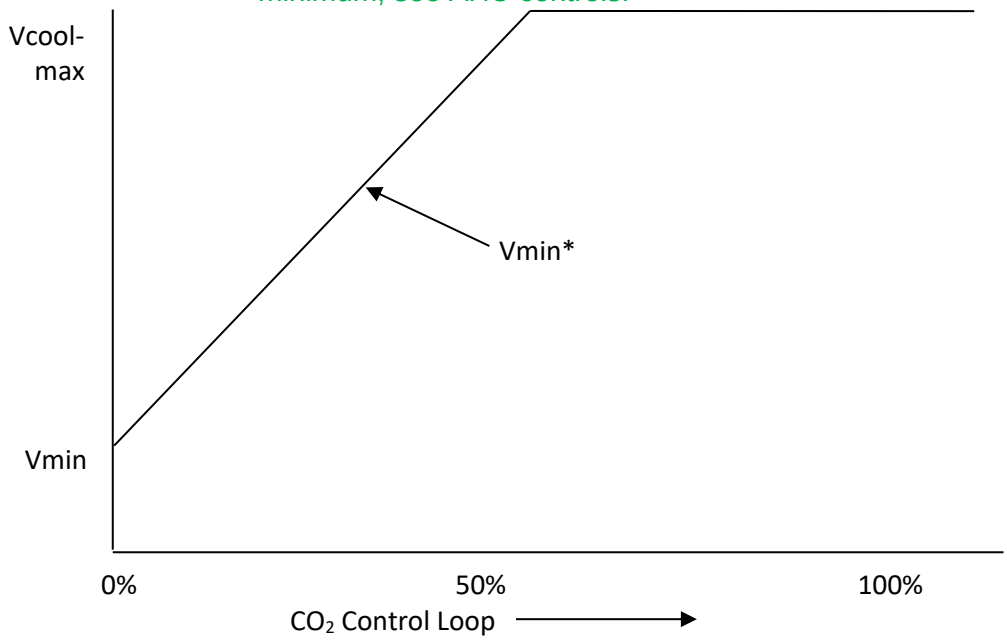


Figure 5.2.1.4-1 Vmin* reset with CO2 loop.

   e) For SZVAV AHUs:
      1. The minimum outdoor air setpoint MinOAsp shall be reset based on the zone CO2 control-loop signal from MinOA at 0% signal to DesOA at 100% signal. See Figure 5.2.1.4-3.

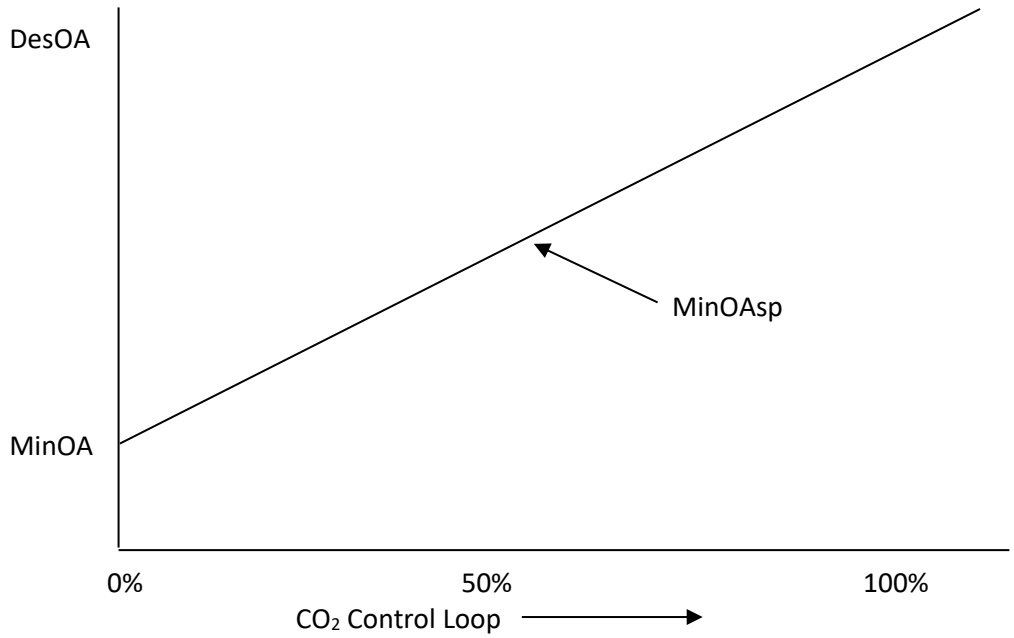


Figure 5.2.1.4-3 Vmin* reset with CO2 loop (SZVAV).

B. Time-Averaged Ventilation

ASHRAE Standard 62.1 and California Title 24 allow for ventilation to be provided based on average conditions over a specific period of time. This time-averaging method allows for zone airflows to effectively be controlled to values below the VAV box controllable minimum value, which may reduce energy use and the risk of overcooling when the zone ventilation requirement is less than the VAV box controllable minimum.

1. When the active airflow setpoint Vspt is nonzero and is less than the lowest possible airflow setpoint allowed by the controls (Vm), the airflow setpoint shall be pulse width modulated as follows:
   a. The time-averaged ventilation (TAV) ratio shall be determined as TAVratio = Vspt/Vm
   b. The total cycle time (TCT) shall be 15 minutes (adjustable)
   c. Open period. During the open period, the TAV airflow setpoint Vspt* shall be equal to Vm for a period of time OP, which is the larger of the following:
   d. 1.5 minutes or
   e. TCT multiplied by TAVratio
   f. Closed period. During the closed period, Vspt* shall be set to 0 for a period of time CP, where CP = TCT – OP. The VAV damper control loop shall be disabled with output set equal to 0 during the closed period. At the end of each closed period, the VAV damper shall be commanded to the last position from the previous open period prior to reenabling the control loop.
   g. During TAV mode, each cycle shall consist of an open and closed period that alternate until Vspt is greater than Vm.

The following logic ensures that multiple zones do not enter TAV mode at the same time, avoiding the synchronized opening and closing of VAV dampers. Where there are a small number of zones and the majority may potentially be in TAV mode synchronously, avoiding this issue may be more reliably achieved by sequencing the

VAV terminal units deterministically so that each VAV terminal unit always opens at a specific minute into the total cycle time. The aim of this sequencing is to ensure that the total airflow is as constant as possible over the total cycling time even if all of the VAV terminal units enter TAV mode at the same time (e.g., when a building-wide temperature setback occurs).
For example, the total open cycle for VAV terminal-unit A opens at minute 1 of the total cycle time, VAV terminal-unit B opens at minute x of the total cycle time, etc.
The random number for each terminal unit, RNDM, can be determined using a random number generator each time the unit enters TAV mode or set manually to a fixed value. If configured manually, set RNDM for each terminal unit to a unique value within the range of 0.0 to 1.0 such that the values are evenly distributed across the terminal units within a system.

h. When first entering TAV mode, start with an initial open period of duration RNDM*OP, where RNDM is a random number between 0.0 and 1.0.

2. When in TAV mode, the active airflow setpoint, Vspt, shall be overridden to Vspt*.

C. For zones with CO2 sensors:

1. If the CO2 concentration is less than 300 ppm, or the zone is in Unoccupied Mode for more than 2 hours and zone CO2 concentration exceeds 600 ppm, generate a Level 3 alarm. The alarm text shall identify the sensor and indicate that it may be out of calibration.

2. If the CO2 concentration exceeds setpoint plus 10% for more than 10 minutes, generate a Level 3 alarm.

3.3 GENERIC THERMAL ZONES

A. This section applies to all single-zone systems and subzones of air-handling systems, such as VAV boxes, fan-powered boxes, etc.

B. Setpoints

1. See Section 1.2B.1 for zone temperature setpoints.

2. Each zone shall have separate occupied and unoccupied heating and cooling setpoints.

3. The active setpoints shall be determined by the operating mode of the Zone Group (see Section 3.4F).

The following is from addendum e to G36-2021:

a. During occupied mode:
   1) The cooling set point shall be the occupied cooling set point.
   2) The heating set point shall be the occupied heating set point.
b. During warm-up mode:
   1) The cooling set point shall be the unoccupied cooling set point.
   2) The heating set point shall be the unoccupied heating set point until the time remaining until the zone group's occupied start time is less than the

zone's required warm-up time, tz-warmup, at which point the heating set point shall be the occupied heating set point.

c. During cool-down mode:
   1) The cooling set point shall be the unoccupied cooling set point until the time remaining until the zone group's occupied start time is less than the zone's required cool-down time, tz-cooldown, at which point the cooling set point shall be the occupied cooling set point.
   2) The heating set point shall be the unoccupied heating set point.
d. During setback mode:
   1) The cooling set point shall be the unoccupied cooling set point.
   2) The heating set point shall be 2°C (3°F) above the unoccupied heating set point.
e. During setup mode:
   1) The cooling set point shall be 2°C (3°F) below the unoccupied cooling set point.
   2) The heating set point shall be the unoccupied heating set point.
f. During unoccupied mode:
   1) The cooling set point shall be the unoccupied cooling set point.
   2) The heating set point shall be the unoccupied heating set point.

4. The software shall prevent the following:
   a. The heating setpoint from exceeding the cooling setpoint minus 0.5°C (1°F) (i.e., the minimum difference between heating and cooling setpoints shall be 0.5°C [1°F]).
   b. The unoccupied heating setpoint from exceeding the occupied heating setpoint.
   c. The unoccupied cooling setpoint from being less than the occupied cooling setpoint.

5. Where the zone has a local setpoint adjustment knob/button:
   a. The setpoint adjustment offsets established by the occupant shall be software points that are persistent (e.g., not reset daily), but the actual offset used in control logic shall be adjusted based on limits and modes as describe below.
   b. The adjustment shall be capable of being limited in software.

These are absolute limits imposed by programming, which are in addition to the range limits (e.g., ±4°F) of the thermostat adjustment device.

      1) As a default, the active occupied cooling setpoint shall be limited between 22°C (72°F) and 27°C (80°F).
      2) As a default, the active occupied heating setpoint shall be limited between 18°C (65°F) and 22°C (72°F).
   c. The active heating and cooling setpoints shall be independently adjustable, respecting the limits and anti-overlap logic described in Sections 3.3B.3.a and 3.3B.5.b. If zone thermostat provides only a single set-point adjustment, then the adjustment shall move both the active heating and cooling setpoints upward or downward by the same amount, within the limits described in Section 3.3B.5.b.
   d. The adjustment shall only affect occupied setpoints in Occupied Mode, Warmup Mode, and Cooldown Mode and shall have no impact on setpoints in all other modes.

e. At the onset of demand limiting, the local set-point adjustment value shall be frozen. Further adjustment of the setpoint by local controls shall be suspended for the duration of the demand-limit event.

6. Cooling Demand Limit Set-Point Adjustment.
   a. Not used

7. Heating Demand-Limit Set-Point Adjustment.
   a. Not used

8. Window Switches.
   a. Not used

9. Occupancy Sensors.
   a. Not used

10. Hierarchy of Set-Point Adjustments. The following adjustment restrictions shall prevail in order from highest to lowest priority:
    a. Setpoint overlap restriction (Section 3.3B.3.a)
    b. Absolute limits on local setpoint adjustment (Section 3.3B.5.b)
    c. Scheduled setpoints based on Zone Group mode

C. Local Override. When thermostat override buttons are depressed, the call for Occupied Mode operation shall be sent to the Zone Group control for 60 minutes. Local Override shall be capable of being enabled and disabled separately for each thermostat via the graphical user interface; default to disabled.

D. Control Loops

1. Two separate control loops, the Cooling Loop and the Heating Loop, shall operate to maintain space temperature at setpoint.
   a. The Heating Loop shall be enabled whenever the space temperature is below the current zone heating set-point temperature and disabled when space temperature is above the current zone heating setpoint temperature and the loop output is zero for 30 seconds. The loop may remain active at all times if provisions are made to minimize integral windup.
   b. The Cooling Loop shall be enabled whenever the space temperature is above the current zone cooling set-point temperature and disabled when space temperature is below the current zone cooling set-point temperature and the loop output is zero for 30 seconds. The loop may remain active at all times if provisions are made to minimize integral windup.

2. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a software point ranging from 0% (no cooling) to 100% (full cooling).

3. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a software point ranging from 0% (no heating) to 100% (full heating).

4. Loops shall use proportional + integral logic or other technology with similar performance. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable by the operator.

5. See other sections for how the outputs from these loops are used.

E. Zone State

1. Heating. When the output of the space Heating Loop is nonzero and the output of the Cooling Loop is equal to zero.

2. Cooling. When the output of the space Cooling Loop is nonzero and the output of the Heating Loop is equal to zero.

3. Deadband. When not in either heating or cooling.

F. Zone Alarms

1. Zone Temperature Alarms
   a. High-temperature alarm
      1) If the zone is 2°C (3°F) above cooling setpoint for 10 minutes, generate a Level 4 alarm.
      2) If the zone is 3°C (5°F) above cooling setpoint for 10 minutes, generate a Level 3 alarm.
   b. Low-temperature alarm
      1) If the zone is 2°C (3°F) below heating setpoint for 10 minutes, generate a Level 4 alarm.
      2) If the zone is 3°C (5°F) below heating setpoint for 10 minutes, generate a Level 3 alarm.

Default time delay for zone temperature alarm (10 minutes) is intentionally long to minimize nuisance alarms. For critical zones, such as IT closets, consider reducing time delay or setting delay to zero.

   c. Suppress zone temperature alarms as follows:
      1) After zone setpoint is changed per Section 3.1S.
      2) While Zone Group is in Warmup Mode or Cooldown Mode.

The following is from addendum e to G36-2021:

G. Zone Group Mode Requests

1. Zone Group Mode Requests shall be generated by the conditions in each zone and sent to the Zone Group of which the zone is a member.

2. Warm-up Mode Requests
   a. An algorithm provided with the BAS shall calculate the required zone warm-up time, tz-warmup, which shall be less than 3 hours, based on the zone's occupied heating set point, the current zone temperature, the outdoor air temperature, and a heating mass/capacity factor for each zone.
   b. The heating mass/capacity factor may be either manually adjusted or automatically self-tuned by the BAS. If automatic, the tuning process shall be

turned ON or OFF by a software switch to allow tuning to be stopped after the system has been trained.

c. If the zone group is in any mode other than occupied mode, zone window switch(es) indicate that all windows are closed, and the time remaining until the zone group's occupied start time is less than the zone's required warm-up time, tz-warmup, send 1 Warm-up Mode Request; else, send 0 Warm-up Mode Requests.

3. Cooldown Mode Requests
   a. An algorithm provided with the BAS shall calculate the required zone cool-down time, tz-cooldown, which shall be less than 3 hours, based on the zone's occupied heating set point, the current zone temperature, the outdoor air temperature, and a cooling mass/capacity factor for each zone.
   b. The cooling mass/capacity factor may be either manually adjusted or automatically self-tuned by the BAS. If automatic, the tuning process shall be turned ON or OFF by a software switch to allow tuning to be stopped after the system has been trained.
   c. If the zone group is in any mode other than occupied mode, zone window switch(es) indicate that all windows are closed, and the time remaining until the zone group's occupied start time is less than the zone's required cool-down time, t-cooldown, send 1 Cooldown Mode Request; else, send 0 Cooldown Mode Requests.

Warm-up and cooldown modes are used to bring the zone groups up to temperature based on their scheduled occupancy period. The algorithms used in these modes (often referred to as "optimal start") predict the shortest time to achieve occupied set point to reduce the central system energy use based on past performance.
It is recommended to use a global outdoor air temperature not associated with any AHU to determine warm-up start time. This is because unit-mounted OA sensors, which are usually placed in the outdoor air intake stream, are often inaccurate (reading high) when the unit is off due to air leakage from the space through the OA damper.

4. Setback Mode Requests
   a. If the zone group is in unoccupied or setback mode, zone window switch(es) indicate that all zone windows are closed, and zone temperature is less than the unoccupied heating setpoint for 5 minutes, send 1 Setback Mode Request; else, send 0 Setback Mode Requests.

5. Setup Mode Requests
   a. If the zone group is in unoccupied or setup mode, zone window switch(es) indicate that all zone windows are closed, and zone temperature is greater than the unoccupied cooling setpoint for 5 minutes, send 1 Setup Mode Requests; else, send 0 Setup Mode Requests.

3.4 ZONE GROUPS

Zone scheduling groups, or Zone Groups, are sets of zones served by a single air handler that operate together for ease of scheduling and/or in order to ensure sufficient load to maintain stable operation in the upstream equipment. A Zone Group is equivalent to an isolation area as defined in ASHRAE/IES Standard 90.1 and Title 24.

A. Each system shall be broken into separate Zone Groups composed of a collection of one or more zones served by a single air handler. See Section 1.2D for Zone Group assignments.

B. Each Zone Group shall be capable of having separate occupancy schedules and operating modes from other Zone Groups.

C. All zones in each Zone Group shall be in the same zone-group operating mode as defined in Section 3.4F. If one zone in a Zone Group is placed in any zone-group operating mode other than Unoccupied Mode (due to override, sequence logic, or scheduled occupancy), all zones in that Zone Group shall enter that mode.

D. A Zone Group may be in only one mode at a given time.

E. For each Zone Group, provide a set of testing/commissioning software switches that override all zones served by the Zone Group. Provide a separate software switch for each of the zone-level override switches listed under “Testing and Commissioning Overrides” in terminal unit sequences. When the value of a Zone Group’s override switch is changed, the corresponding override switch for every zone in the Zone Group shall change to the same value. Subsequently, the zone-level override switch may be changed to a different value. The value of the zone-level switch has no effect on the value of the zone-group switch, and the value of the zone-group switch only affects the zone-level switches when the zone-group switch is changed.

The testing and commissioning overrides will be specified for each type of terminal unit and system in subsequent sequences. These overrides allow a commissioning agent to, for example, force a zone into cooling or drive a valve all the way open or closed.
Zone-group override switches allow a commissioning agent to apply a zone-level override to all zones in a Zone Group simultaneously. This greatly accelerates the testing and commissioning process.

F. Zone-Group Operating Modes. Each Zone Group shall have the modes shown in the following subsections.

The modes presented in this section are to enable different setpoints and ventilation requirements to be applied to Zone Groups based on their operating schedule, occupancy status, and deviation from current setpoint.
See ASHRAE Guideline 13 for best practices in locating zone-group operating mode programming logic based on network architecture.

1. Occupied Mode. A Zone Group is in the Occupied Mode when any of the following is true:
   a. The time of day is between the Zone Group’s scheduled occupied start and stop times.
   b. Any zone local override timer (initiated by local override button) is nonzero.

The following is from addendum e to G36-2021:

2. Warm-Up Mode. Warm-up mode shall start when the number of Warm-Up Mode Requests > I (I = ignores, default = 5), and shall end at the zone group’s scheduled occupied start time or Warm-Up Mode Requests <MT (MT=minimum threshold, default = 1) after a minimum of 10 minutes in this mode.

3. Cool-down Mode. Cool-down mode shall start when the number of Cool-down Mode Requests > I (I = ignores, default to 5), and shall end at the zone group's scheduled occupied start time or Cool-down Mode Requests <MT (MT=minimum threshold, default = 1) after a minimum of 10 minutes in this mode.

4. Setback Mode. Setback mode shall start when the number of Setback Mode Requests > I (I = ignores, default to 4), and shall end when Setback Mode Requests <MT (MT=minimum threshold, default = 1) after a minimum of 10 minutes in this mode.

5. Setup Mode. Setup mode shall start when the number of Setup Mode Requests > I (I = ignores, default to 4), and shall end when Setup Mode Requests <MT (MT=minimum threshold, default = 1) after a minimum of 10 minutes in this mode.

Setback and setup modes are used to keep zone temperatures (and mass) from straying excessively far from occupied set points so that the cooldown and warm-up modes can achieve set point when initiated. The number of ignored zones (set at 4 here) are to ensure that the central systems (fans, pumps, heating sources, or cooling sources) can operate stably. Obviously, the size of the zones and the characteristics of the central systems are a factor in choosing the correct number of zones in each group.

6. When zones in one Zone Group are generating requests for different modes, the hierarchy in Section 5.15.1 shall be used to determine Zone Group Operating Mode.

3.5 VAV TERMINAL UNIT WITH REHEAT

A. See "Generic Thermal Zones" (Section 3.2C) for setpoints, loops, control modes, alarms, etc.

B. See "Generic Ventilation Zones" (Section 3.2) for calculation of zone minimum outdoor airflow.

C. See Section 1.2C.2 for zone minimum airflow setpoints Vmin, zone maximum cooling airflow setpoint Vcool-max, zone maximum heating airflow setpoint Vheat-max, zone minimum heating airflow setpoint Vheat-min, and the maximum DAT rise above heating setpoint MaxΔT.

D. Active endpoints used in the control logic depicted in Figure 5.6.5 shall vary depending on the mode of the Zone Group the zone is a part of (see Table 5.6.4).

Table 5.6.4 Endpoints as a Function of Zone Group Mode

Endpoint	Occupied	Cooldown	Setup	Warmup	Setback	Unoccupied
Cooling maximum	Vcool-max	Vcool-max	Vcool-max	0	0	0
Cooling minimum	Vmin*	0	0	0	0	0

Minimum	Vmin*	0	0	0	0	0
Heating minimum	Max (Vheat-min, Vmin*)	Vheat-min	0	Vheat-max	Vheat-max	0
Heating maximum	Max (Vheat-max, Vmin*)	Vheat-max	0	Vcool-max	Vcool-max	0

E. Control logic is depicted schematically in Figure 5.6.5 (modified from Guideline 36) and described in the following subsections.

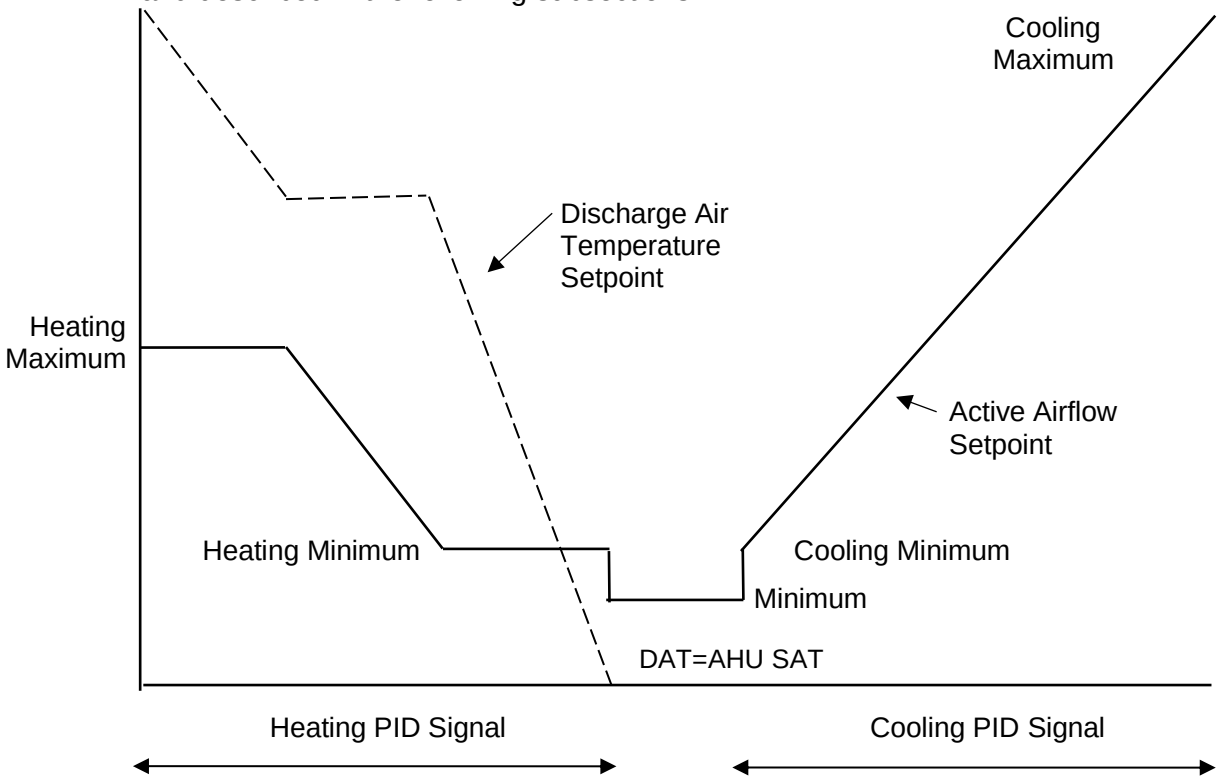


Figure 5.6.5 Control logic for VAV reheat zone modified from Guideline 36.

1. When the Zone State is cooling, the cooling-loop output shall be mapped to the active airflow setpoint from the cooling minimum endpoint to the cooling maximum endpoint. Heating coil is disabled unless the DAT is below the minimum setpoint (see Section 3.5E.4).
   a. If supply air temperature from the air handler is greater than room temperature, the active airflow setpoint shall be no higher than the minimum endpoint.

2. When the Zone State is deadband, the active airflow setpoint shall be the minimum endpoint. Heating coil is disabled unless the DAT is below the minimum setpoint (see Section 3.5E.4).

3. When the Zone State is heating, the Heating Loop shall maintain space temperature at the heating setpoint as follows:
   a. From 0 to 33%, the Heating Loop output shall reset the discharge air temperature DAT from the current AHU SAT setpoint to a setpoint equal to MaxΔT above space temperature setpoint. The airflow setpoint shall be the Heating Minimum.
   b. From 33% to 66%, if the DAT is greater than the room temperature plus 5ºF, the Heating Loop output shall reset the zone airflow setpoint from the Heating Minimum to the Heating Maximum endpoint.
   c. From 66% to 100%, the Heating Loop output shall reset the DAT setpoint to 115°F.
   d. The heating coil shall be modulated to maintain the discharge temperature at setpoint. (Directly controlling heating off the zone temperature control loop is not acceptable).
      1) When the airflow setpoint is pulse-width modulated per Section 3.2B, the heating coil and PID loop shall be disabled, with output set to 0 during closed periods.

4. In Occupied Mode, the heating coil shall be modulated to maintain a DAT no lower than 10°C (50°F).

5. The VAV damper shall be modulated by a control loop to maintain the measured airflow at the active setpoint.

F. Alarms

1. Low Airflow
   a. If the measured airflow is less than 70% of setpoint for 10 minutes while setpoint is greater than zero, generate a Level 4 alarm.
   b. If the measured airflow is less than 50% of setpoint for 10 minutes while setpoint is greater than zero, generate a Level 3 alarm.
   c. If a zone has an Importance-Multiplier of 0 (see Section 3.1O.2.a.1)) for its static pressure reset T&R control loop, low airflow alarms shall be suppressed for that zone.

2. Low-Discharge Air Temperature
   a. If heating hot-water plant is proven on, and the DAT is 8.3°C (15°F) less than setpoint for 10 minutes, generate a Level 4 alarm.
   b. If heating hot-water plant is proven on, and the DAT is 17°C (30°F) less than setpoint for 10 minutes, generate a Level 3 alarm.
   c. If a zone has an Importance-Multiplier of 0 (see Section 3.1O.2.a.1)) for its hot-water reset T&R control loop, low-DAT alarms shall be suppressed for that zone.

3. Airflow Sensor Calibration. If the fan serving the zone is off and airflow sensor reading is above the larger of 10% of the cooling maximum airflow setpoint or 50 cfm for 30 minutes, generate a Level 3 alarm.

4. Leaking Damper. If the damper position is 0%, and airflow sensor reading is above the larger of 10% of the cooling maximum airflow setpoint or 50 cfm for 10 minutes while the fan serving the zone is proven on, generate a Level 4 alarm.

5. Leaking Valve. If the valve position is 0% for 15 minutes, DAT is above AHU SAT by 3°C (5°F), and the fan serving the zone is proven on, generate a Level 4 alarm.

G. Testing/Commissioning Overrides. Provide software switches that interlock to a system level point to
   a. force zone airflow setpoint to zero,
   b. force zone airflow setpoint to Vcool-max,
   c. force zone airflow setpoint to Vmin,
   d. force zone airflow setpoint to Vheat-max,
   e. force damper full closed/open,
   f. force heating to off/closed, and
   g. reset request-hours accumulator point to zero (provide one point for each reset type listed in the next section).

H. System Requests

1. Cooling SAT Reset Requests
   a. If the zone temperature exceeds the zone's cooling setpoint by 3°C (5°F) for 2 minutes and after suppression period due to setpoint change per Section 3.1S, send 3 requests.
   b. Else if the zone temperature exceeds the zone's cooling setpoint by 2°C (3°F) for 2 minutes and after suppression period due to setpoint change per Section 3.1S, send 2 requests.
   c. Else if the Cooling Loop is greater than 95%, send 1 request until the Cooling Loop is less than 85%.
   d. Else if the Cooling Loop is less than 95%, send 0 requests.

2. Static Pressure Reset Requests
   a. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 requests.
   b. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 requests.
   c. Else if the damper position is greater than 95%, send 1 request until the damper position is less than 85%.
   d. Else if the damper position is less than 95%, send 0 requests.

3. If There Is a Hot-Water Coil, Hot-Water Reset Requests
   a. If the DAT is 17°C (30°F) less than setpoint for 5 minutes, send 3 requests.
   b. Else if the DAT is 8°C (15°F) less than setpoint for 5 minutes, send 2 requests.
   c. Else if HW valve position is greater than 95%, send 1 request until the HW valve position is less than 85%.
   d. Else if the HW valve position is less than 95%, send 0 requests.

4. If There Is a Hot-Water Coil and Heating Hot-Water Plant, Heating Hot-Water Plant Requests. Send the heating hot-water plant that serves the zone a heating hot-water plant request as follows:

a. If the HW valve position is greater than 95%, send 1 request until the HW valve position is less than 10%.
b. Else if the HW valve position is less than 95%, send 0 requests.

3.6 LABORATORY VAV REHEAT ZONE

A. See “Generic Thermal Zones” (Section 3.3) for setpoints, loops, control modes, alarms, etc.

B. See Section 1.2D for airflow and discharge air temperature setpoints.

C. The SOOs in the section have been programmed already for the Contra Costa College Science Center project and will be made available to this project. Changes to that SOO are shown herein in red text.

D. Lab air terminal controllable minimum

1. Supply air terminal controllable minimum (Vctrl-min) and general exhaust air valve controllable minimum (Vgex-ctrl-min) shall be determined in accordance with Paragraph 1.4B.

2. Where there is more than one terminal, rates shall be added together for control logic below.

E. Pressurization control

1. Sign conventions: All airflows have a positive sign, except for the room offset airflow which may be positive (for positively pressurized lab) or negative (for negatively pressurized lab.

2. The active supply air minimum Vmin* shall be equal to the larger of the following but no larger than Vmax:
   a. Exhaust makeup air rate, Vmu
   b. Minimum ventilation rate (Vvent) equal to
      1) If the zone is unoccupied as indicated by its occupancy sensor and the lab is scheduled to be unoccupied, Vmin-unocc.
      2) Otherwise, Vmin-occ
   c. Vctrl-min

3. Vgex-step shall be equal to Vgex-ctrl-minimum
   1) The active airflow setpoint Vstp for temperature control is equal to Vmin*, and
   2) The larger of Vvent and Vctrl-min has been less than or equal to the sum of the following for 30 seconds or more:
      a) Sum of fume hood exhaust valve(s) airflow feedback
      b) Vother
      c) Voffset

4. The make-up airflow demand (Vmu) is equal to the sum of:
   a. Sum of fume hood exhaust valve(s) airflow feedback
   b. Vgex-step

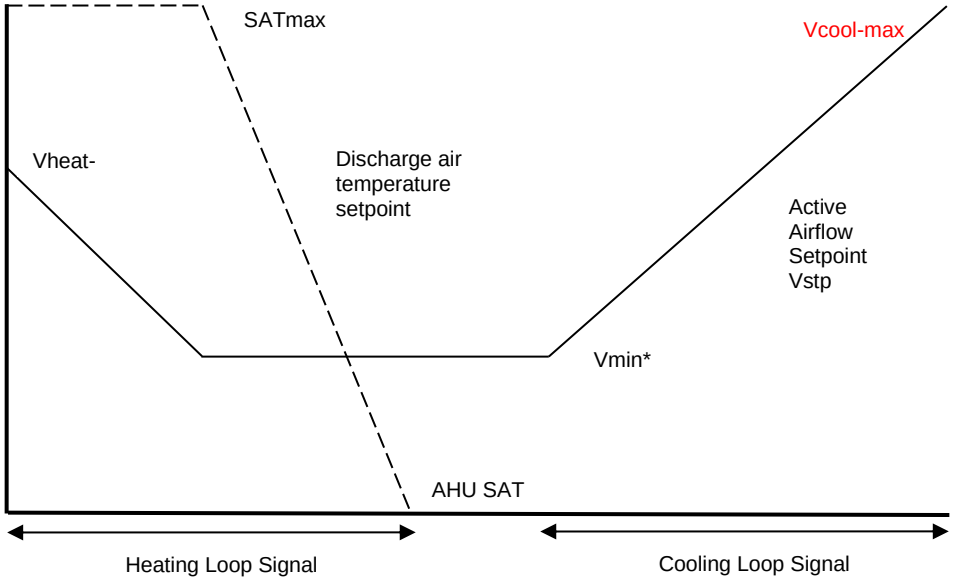
c. Vother
d. Voffset

5. The active general exhaust valve setpoint Vgex-spt shall equal 0 when Vgex-step is equal 0; otherwise it shall equal the sum of the following but no larger than Vgex-max:
   a. Supply valve feedback airflow minus Vmu
   b. The general exhaust valve controllable minimum airflow, Vgex-ctrl-min

F. Supply air

1. Active endpoints used in the control logic depicted in the figure below shall not vary regardless of the Mode of the Zone Group the zone is a part of.

2. Control logic is depicted schematically in the figure below and described in the following sections.



3. When the Zone State is Cooling, the Cooling Loop output shall be mapped to the active airflow setpoint from the Vmin* to Vcool-max, but no lower than Vmin*.
   a. If supply air temperature from the air handler is greater than room temperature, the active airflow setpoint shall be no higher than Vmin*

4. When the Zone State is Deadband, the active airflow setpoint shall be Vmin*.

5. When the Zone State is Heating:
   a. From 0-50%, the Heating Loop output shall reset the discharge temperature setpoint from the current AHU SAT setpoint to SATmax. The active airflow setpoint shall be Vmin*.
   b. From 51%-100%, if the discharge air temperature is greater than room temperature plus 3°C (5°F), the Heating Loop output shall reset the active airflow setpoint from the Vmin* to Vheat-max.

6. If the current supply air temperature from the AHU is less than the current heating coil discharge air setpoint, the heating coil shall be modulated to maintain the discharge temperature at setpoint. (Directly controlling heating off the zone temperature control loop is not acceptable).

7. Where drawings indicate supply air valves have on-board controllers, the airflow setpoint is sent to the controller and the controller modulates the VAV damper to maintain the measured airflow at setpoint.

8. Where drawings indicate supply air valves are controlled by the BAS, the VAV damper shall be modulated to maintain the measured airflow at setpoint.

G. General exhaust

1. Where drawings indicate general exhaust air valves have on-board controllers, the active airflow setpoint Vgex-spt is sent to the controller and the controller modulates the VAV damper to maintain the measured airflow at setpoint.

2. Where drawings indicate general exhaust air valves are controlled by the BAS, the VAV damper shall be modulated to maintain the measured airflow at the active airflow setpoint Vgex-spt.

H. Alarms

1. Airflow alarm
   a. If the airflow feedback from any valve is 15% above or below setpoint for 5 minutes, generate a Level 3 alarm.
   b. If the airflow feedback from any valve is 30% above or below setpoint for 5 minutes, generate a Level 2 alarm.

2. Room pressurization polarity alarm
   a. Generate a Level 2 alarm if the airflow offset has incorrect polarity for 5 minutes based on sum of exhaust feedback signals and supply feedback signal:
      1) For a room with negative offset, if exhaust minus supply < 0
      2) For a room with positive offset, if exhaust minus supply > 0

3. Room low supply rate alarm
   a. If the sum of exhaust feedback signals exceeds supply feedback signal by more than 4 times (adjustable) the offset for 1 minute:
      1) Generate a Level 1 alarm (high level due to problems exiting)
      2) All fume hood exhaust setpoints shall be reduced to a fixed percentage of the maximum hood rates; this percentage shall be determined as specified in Section 230593 Testing, Adjusting and Balancing.

4. Low supply air temperature
   a. If boiler plant is proven on and the supply air temperature is 15°F less than setpoint for 10 minutes, generate a Level 3 alarm.
   b. If boiler plant is proven on and the supply air temperature is 30°F less than setpoint for 10 minutes, generate a Level 2 alarm.

5. High supply air temperature
   a. If chiller plant is proven on and the supply air temperature is 10°F more than setpoint for 10 minutes, generate a Level 3 alarm.
   b. If chiller plant is proven on and the supply air temperature is 20°F more than setpoint for 10 minutes, generate a Level 2 alarm.

6. Fume hood
   a. Fume hood alarm: Level 2
   b. If average sash height (interpolated based on average cfm feedback through the hood and design maximum and minimum setpoints) during the last 24 hours is greater than 50% (adjustable), generate a Level 4 alarm

I. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to

1. Force supply airflow setpoint to zero

2. Force supply airflow setpoint to Vmax

3. Force supply airflow setpoint to Vmin

4. Force supply damper full closed/open

5. Force heating valve to closed/open

6. Force hood exhaust airflow setpoint to Vhex-max

7. Force hood exhaust airflow setpoint to Vhex-min

8. Force general exhaust airflow setpoint to Vgex-max

9. Force general exhaust airflow setpoint to Vgex-ctrl-min

10. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)

J. System Requests

1. Cooling SAT Reset Requests
   a. If the zone temperature exceeds the zone's cooling setpoint by 3°C (5°F) for 2 minutes and after suppression period due to setpoint change, send 3 Requests,
   b. Else if the zone temperature exceeds the zone's cooling setpoint by 2°C (3°F) for 2 minutes and after suppression period due to setpoint change, send 2 Requests,
   c. Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%,
   d. Else if the Cooling Loop is less than 95%, send 0 Requests

2. Exhaust or Supply Static Pressure Reset Requests (Feedback loop type valves; separately include all exhaust and supply air valves in zone)

a. If the measured airflow is less than 85% of setpoint (except those zones where the setpoint is unknown e.g. hood exhaust valves) for 30 seconds, send 3 requests,
b. Else if the Damper Loop is greater than 95%, send 1 request,
c. Else if the Damper Loop is less than 85%, send 0 requests.

3. If there is a hot water coil, Hot Water Reset Requests
   a. If the discharge air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests,
   b. Else if the discharge air temperature is 8°C (15°F) less than setpoint for 5 minutes, send 2 Requests,
   c. Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,
   d. Else if the HW valve position is less than 95%, send 0 Requests

4. If there is a hot water coil, Heating Hot Water Plant Requests. Send the heating hot water plant that serves the zone a Heating Hot Water Plant Request as follows:
   a. If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%
   b. Else if the HW valve position is less than 95%, send 0 Requests.

3.7 AIR-HANDLING UNIT SYSTEM MODES (AC-1, AH-2, AH-3)

A. AHU system modes are the same as the mode of the Zone Group served by the system. When Zone Group served by an air-handling system are in different modes, the following hierarchy applies (highest one sets AHU mode):
   a. Occupied Mode
   b. Cooldown Mode
   c. Setup Mode
   d. Warmup Mode
   e. Setback Mode
   f. Unoccupied Mode

3.8 MULTIPLE ZONE VAV AIR HANDLERS (AH-2, AH-3)

A. Supply Fan Control

1. Supply Fan Start/Stop
   a. AHU-2 shall operate in Occupied Mode regardless of Zone Group modes. (Zone controls will provide the zone desired temperature and airflow setpoints based on Zone Group Mode, but AHU operation is the same regardless.)
   b. AHU-3 shall operate in all modes except Unoccupied Mode.
   c. Totalize current airflow rate from VAV boxes to a software point Vps.

VAV box airflow rates are summed to obtain overall supply air rate without the need for an airflow measuring station (AFMS) at the air-handler discharge. This is used for ventilation rate calculations and may also be used for display and diagnostics.

2. Static Pressure Set-Point Reset
   a. Static pressure setpoint. Setpoint shall be reset using T&R logic (see Section 3.1O) using the parameters shown in Table 5.16.1.2.

Table 5.16.1.2 Trim & Respond Variables

Variable	Value
Device	Supply fan
SP0	120 Pa (0.5 in. of water)
SPmin	25 Pa (0.1 in. of water)
SPmax	Max_DSP (see Section 1.3B.1)
Td	10 minutes
T	2 minutes
I	2
R	Zone static pressure reset requests
SPtrim	–12 Pa (–0.05 in. of water)
SPres	15 Pa (+0.06 in. of water)
SPres-max	32 Pa (+0.13 in. of water)

The T&R reset parameters in Table 5.16.1.2 are suggested as a starting point; they will most likely require adjustment during the commissioning/tuning phase.

3. Static Pressure Control
   a. Supply fan speed is controlled to maintain DSP at setpoint when the fan is proven on. Where the Zone Groups served by the system are small, provide multiple sets of gains that are used in the control loop as a function of a load indicator (such as supply-fan airflow rate, the area of the Zone Groups that are occupied, etc.).

High-pressure trips may occur if all VAV boxes are closed (as in Unoccupied Mode) or if fire/smoke dampers are closed (in some fire/smoke damper (FSD) designs, the dampers are interlocked to the fan status rather than being controlled by smoke detectors). Multiple sets of gains are used to provide control loop stability as system characteristics change.

B. Supply Air Temperature Control

1. Control loop is enabled when the supply air fan is proven on, and disabled and output set to deadband (no heating, minimum economizer) otherwise.

2. Supply Air Temperature Setpoint

The default range of outdoor air temperatures [21°C (70°F) –16°C (60°F)] used to reset the Occupied Mode SAT setpoint was chosen to maximize economizer hours. It may be preferable to use a lower range of OATs (e.g., 18°C [65°F] – 13°C [55°F]) to minimize fan energy if there is a 24/7 chiller plant that is running anyway; reheat is minimized, as in a VAV dual-fan dual-duct system, or the climate severely limits the number of available economizer hours.

If using this logic, the engineer should oversize interior zones and rooms with high cooling loads (design them to be satisfied by the warmest SAT) so these zones do not drive the T&R block to the minimum SAT setpoint.

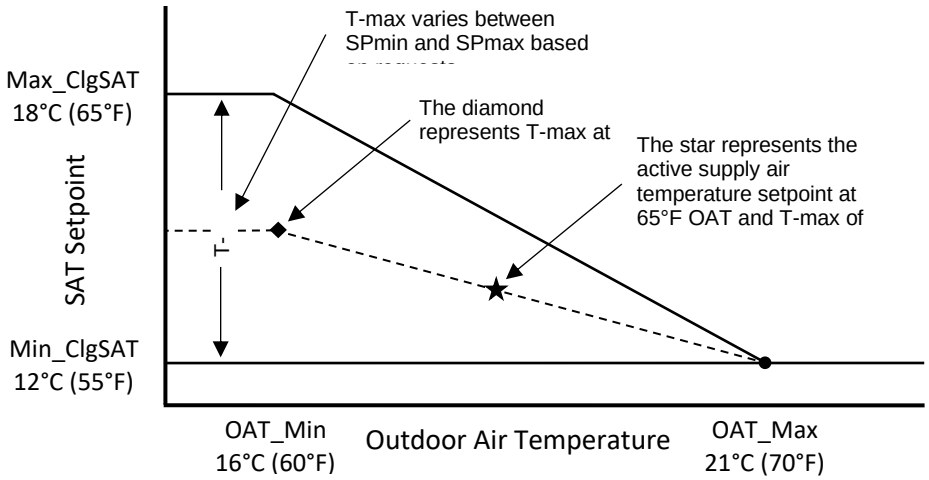
a. See Section 1.2F.1 for Min_ClgSAT, Max_ClgSAT, OAT_Min, and OAT_Max setpoints.
b. During Occupied Mode and Setup Mode, setpoint shall be reset from Min_ClgSAT when the outdoor air temperature is OAT_Max and above, proportionally up to T-max when the outdoor air temperature is OAT_Min and below.
    1) T-max shall be reset using T&R logic (see Section 3.1O) between Min_ClgSAT and Max_ClgSAT. The parameters shown in Table 5.16.2.2 are suggested as a starting place, but they will require adjustment during the commissioning/tuning phase.

The T&R reset parameters in Table 5.16.2.2 are suggested as a starting place; they will most likely require adjustment during the commissioning/tuning phase.

Table 5.16.2.2 Trim & Respond Variables

Variable	Value
Device	Supply fan
SP0	SPmax
SPmin	Min_ClgSAT
SPmax	Max_ClgSAT
Td	10 minutes
T	2 minutes
I	2
R	Zone cooling SAT requests
SPtrim	+0.1°C (+0.2°F)
SPres	–0.2°C (–0.3°F)
SPres-max	–0.6°C (–1.0°F)

The net result of this SAT reset strategy is depicted in the Figure 5.16.2.2 for Min_ClgSAT = 12°C (55°F), Max_ClgSAT = 18°C (65°F), OAT_Max = 21°C (70°F), and OAT_Min = 16°C (60°F).



Informative Figure 5.16.2.2 Example supply air temperature reset diagram.

c. During Cooldown Mode, setpoint shall be Min_ClgSAT.
d. During Warmup Mode and Setback Mode, setpoint shall be 35°C (95°F).

Raising the SAT setpoint in warmup will effectively lock out the economizer and cooling coil, which is desirable for warmup even if there is no heating coil at the AHU to meet the higher SAT.
This does not apply in the case of a DFDD AHU or if all the zones are equipped with fan-powered boxes such that the AHU is off in warmup and setback.

3. Supply air temperature shall be controlled to setpoint using a control loop whose output is mapped to sequence the heating coil (if applicable), outdoor air damper, return air damper, and cooling coil as shown in Figure 5.16.2.3.
   a. For units with return fans
      1) Return air damper maximum position MaxRA-P is modulated to control minimum outdoor air volume (see Section 3.8D.2).
      2) For units with a single common minimum outdoor air and economizer damper, return air damper maximum position MaxRA-P and economizer damper minimum position MinOA-P are modulated to control minimum outdoor air volume (see Section 3.8D). Economizer damper maximum position MaxOA-P is limited during minimum outdoor air control (e.g., economizer lockout due to high OAT).
   b. The points of transition along the x-axis shown and described in Figure 5.16.2.3 are representative. Separate gains shall be provided for each section of the control map (heating coil, economizer, cooling coil) that is determined by the contractor to provide stable control. Alternatively, the contractor shall adjust the precise value of the x-axis thresholds shown in Figure 5.16.2.3 to provide stable control. Damper control depends on the type of building pressure control system.

For AHUs with return fans and direct building pressure controls, the SAT control loop makes the economizer outdoor air damper open fully whenever the AHU is on, while the return air damper modulates to maintain supply air temperature as shown below. Relief/exhaust damper position tracks inversely with the return damper position.

Outdoor air dampers on air handlers with return fans have no impact on the outdoor airflow rate into the mixing plenum. Instead, the return-fan and return-damper controls dictate outdoor air flow. See ASHRAE Guideline 16.
Note that the economizer damper will close (if there is a separate minimum outdoor air damper) or modulate to minimum position (if there is a single outdoor air damper) whenever minimum outdoor air control is active. See logic for Minimum Outdoor Air Control below.

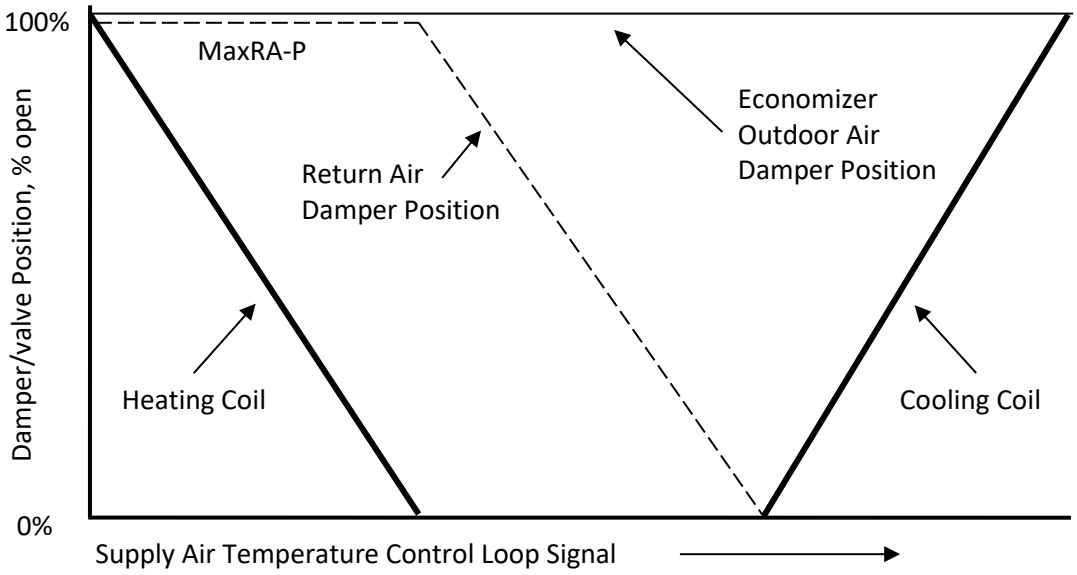


Figure 5.16.2.3 SAT loop mapping with return-fan control with direct building pressure controls.

C. Minimum Outdoor Airflow Setpoints

1. Outdoor Airflow Setpoint for California Title 24 Ventilation
   a. See Section 3.2A.3 for zone outdoor air rates Zone-Abs-OA-min and Zone-Des-OA-min.
   b. See Section 1.2F.2.a for setpoints AbsMinOA and DesMinOA.
   c. Effective outdoor air absolute minimum and design minimum setpoints are recalculated continuously based on the mode of the zones being served.
      1) AbsMinOA* is the sum of Zone-Abs-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the absolute minimum outdoor airflow AbsMinOA.
      2) DesMinOA* is the sum of Zone-Des-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the design minimum outdoor airflow DesMinOA.

D. Minimum Outdoor Air Control with a Single Common Damper for Minimum Outdoor Air and Economizer Functions and Airflow Measurement

1. Outdoor Airflow Setpoint for California Title 24 Ventilation
   a. See Section 3.8C.1 for calculation of current setpoints AbsMinOA* and DesMinOA*.

b. See zone CO2 control logic under terminal unit sequences.
c. The minimum outdoor air setpoint MinOAsp shall be reset based on the highest zone CO2 control-loop signal from AbsMinOA* at 50% signal to DesMinOA* at 100% signal.

2. Minimum Outdoor Air Control Loop
   a. Minimum outdoor air control loop is enabled when the supply fan is proven on and the AHU is in Occupied Mode, and disabled and output set to zero otherwise.
   b. For units with return fans:

The following logic limits the return damper position to ensure that minimum outdoor air is maintained at all times, while the actual return damper position is modulated by the SAT control loop.

1) The outdoor airflow rate shall be maintained at the minimum outdoor damper outdoor airflow setpoint MinOAsp by a direct-acting control loop whose output is mapped to the return air damper maximum position endpoint MaxRA-P.

The following logic directly controls the return damper position to ensure that exactly the minimum outdoor air – and no more – is provided when economizer lockout conditions are exceeded. When economizer lockout no longer applies, return damper control reverts to the SAT control loop.

2) While the unit is in Occupied Mode, if the economizer high limit conditions in Section 3.1Q are exceeded for 10 minutes, outdoor air shall be controlled to the minimum outdoor airflow. When this occurs, the normal sequencing of the return air damper by the SAT control loop is suspended, and the return air damper position shall be modulated directly to maintain measured airflow at MinOAsp (i.e. return damper position shall equal MaxRA-P). The economizer damper shall remain open.
3) If the economizer high limit conditions in Section 3.1Q are not exceeded for 10 minutes, or the unit is no longer in Occupied Mode, release return damper to control by the SAT control loop (i.e. return damper position is limited by MaxRA-P endpoint, but is not directly controlled to equal MaxRA-P).

E. Return-Fan Control − Direct Building Pressure

1. See Section 1.2F.4 for pressure Zone Group assignments.

2. Return fan operates whenever the associated supply fan is proven on and shall be off otherwise.

3. Return fans shall be controlled to maintain return-fan discharge static pressure at setpoint (Section 3.8E.5).

4. Building static pressure shall be time averaged with a sliding 5-minute window and 15 second sampling rate (to dampen fluctuations). The averaged value shall be that displayed and used for control.
   a. Where multiple building pressure sensors are used, the highest of the averaged values for sensors within a pressure zone shall be used for control.

Due to the potential for interaction between the building pressurization and return-fan control loops, extra care must be taken in selecting the control loop gains. To prevent excessive control-loop interaction, the closed-loop response time of the building pressurization loop should not exceed 1/5 the closed-loop response time of the return-fan control loop. This can be accomplished by decreasing the gain of the building pressurization control loop.

5. A single P-only control loop for each pressure zone shall modulate to maintain the building pressure at a setpoint of 12 Pa (0.05 in. of water) with an output ranging from 0% to 100%. The loop shall be enabled when the supply and return fans for any unit within the pressure zone are proven ON and the minimum outdoor air damper is open. The exhaust dampers shall be closed with loop output set to zero otherwise. All exhaust damper and return fan static pressure setpoints for units in an associated pressure zone shall be sequenced based on building pressure control loop output signal, as shown in Figure 5.16.10.5.

A pressure zone is defined as an enclosed area with interconnected return air paths. All operating relief dampers and return fans that serve a pressure zone shall be controlled as if they were one system, using the same control loop, even if they are associated with different AHUs.
The appropriate boundaries for pressure zones, establishing which return fans run together, will need to be determined by the engineer based on building geometry.

   a. From 0% to 50%, the building pressure control loop shall modulate the exhaust dampers from 0% to 100% open.
   b. From 51% to 100%, the building pressure control loop shall reset the return-fan discharge static pressure setpoint from RFDSPmin at 50% loop output to RFDSPmax at 100% of loop output. See Section 1.3B.3 for RFDSPmin and RFDSPmax.

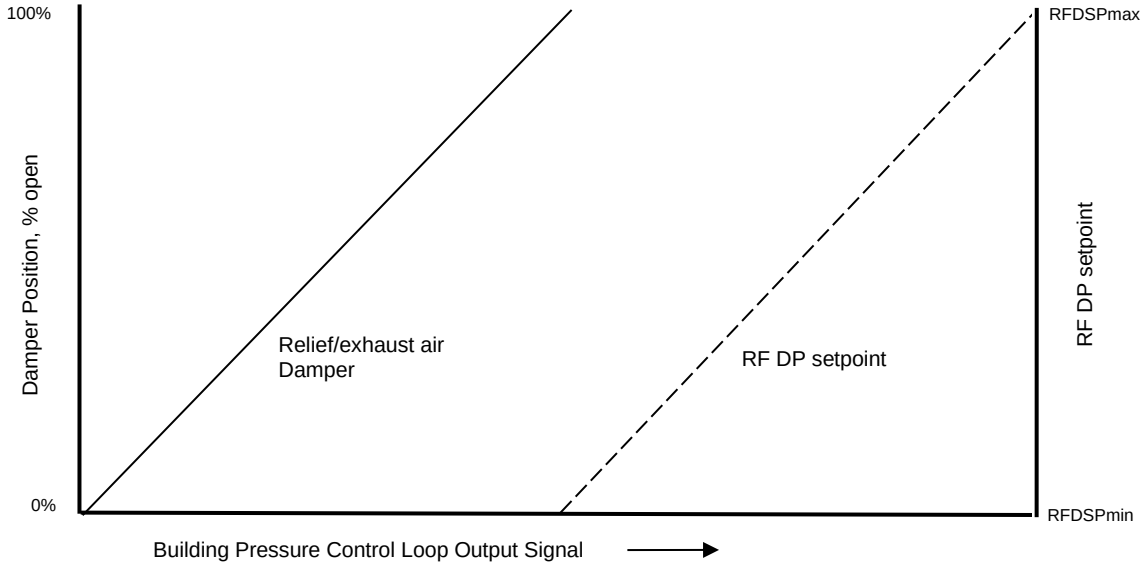


Figure 5.16.10.5 Exhaust damper position and return-fan DP reset

F. Alarms

1. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval count when alarm is acknowledged.

2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   a. Commanded on, status off: Level 2
   b. Commanded off, status on: Level 4

3. Dirty filter: Level 4.

4. High building pressure (more than 25 Pa [0.10 in. of water]) for 5 minutes: Level 3.

5. Low building pressure (less than 0 Pa [0.0 in. of water], i.e., negative) for 5 minutes: Level 4.

Automatic fault detection and diagnostics (AFDD) is a sophisticated system for detecting and diagnosing air-handler faults.
To function correctly, AFDD requires specific sensors and data be available, as detailed in the sequences below. If this information is not available, AFDD tests that do not apply should be deleted.

G. Automatic Fault Detection and Diagnostics

The AFDD routines for AHUs continually assess AHU performance by comparing the values of BAS inputs and outputs to a subset of potential fault conditions. The subset of potential fault conditions that is assessed at any point depends on the operating state (OS) of the AHU, as determined by the position of the cooling and heating valves and the economizer damper. Time delays are applied to the evaluation and reporting of fault conditions to suppress false alarms. Fault conditions that pass these filters are reported to the building operator along with a series of possible causes.
These equations assume that the air handler is equipped with hydronic heating and cooling coils, as well as a fully integrated economizer. If any of these components are not present, the associated tests and variables should be omitted from the programming.
Note that these alarms rely on reasonably accurate measurement of mixed air temperature. An MAT sensor is required for many of these alarms to work, and an averaging sensor is strongly recommended for best accuracy.

1. AFDD conditions are evaluated continuously and separately for each operating AHU.

2. For units with return fans:
   a. The OS of each Ahu shall be defined by the commanded positions of the heating coil control valve, cooling coil control valve and the return air damper in accordance with Table 2.

Table 2 VAV AHU Operating States

Operating State	Heating Valve Position	Cooling Valve Position	Return Air Damper Position
#1: Heating	> 0	= 0	= MaxRA-P

#2: Free cooling, modulating OA	= 0	= 0	MaxRA-P > x > 0%
#3: Mechanical + economizer cooling	= 0	> 0	= 0%
#4: Mechanical cooling, minimum OA	= 0	> 0	= MaxRA-P
#5: Unknown or dehumidification	No other OS applies		

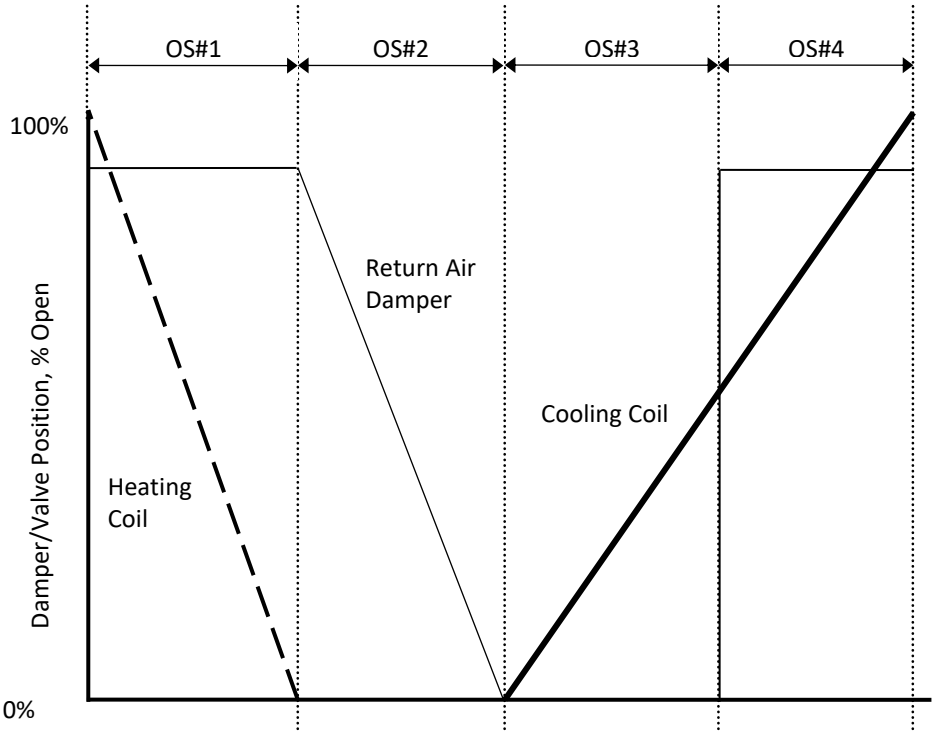


Figure 2 VAV AHU operating states.

3. The following points must be available to the AFDD routines for each AHU:

For the AFDD routines to be effective, an averaging sensor is recommended for SAT. An averaging sensor is essential for MAT, as the environment of the mixing box will be subject to nonuniform and fluctuating air temperatures. It is recommended that the OAT sensor be located at the AHU so that it accurately represents the temperature of the incoming air.

a. SAT = supply air temperature
b. MAT = mixed air temperature
c. RAT = return air temperature
d. OAT = outdoor air temperature
e. DSP = duct static pressure
f. SATSP = supply air temperature setpoint
g. DSPSP = duct static pressure setpoint
h. HC = heating-coil valve position command; 0% □ HC □ 100%
i. CC = cooling-coil valve position command; 0% □ CC □ 100%
j. FS = fan speed command; 0% □ FS □ 100%

k. CCET = cooling-coil entering temperature (Depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.)
l. CCLT = cooling-coil leaving temperature (Depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.)
m. HCET = heating-coil entering temperature (Depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.)
n. HCLT = heating-coil leaving temperature (Depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.)

4. The following values must be continuously calculated by the AFDD routines for each AHU:
   a. Five-minute rolling averages with 1-minute sampling time of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently.
      1) SATavg = rolling average of supply air temperature
      2) MATavg = rolling average of mixed air temperature
      3) RATavg = rolling average of return air temperature
      4) OATavg = rolling average of outdoor air temperature
      5) DSPavg = rolling average of duct static pressure
      6) CCETavg = rolling average of cooling-coil entering temperature
      7) CCLTavg = rolling average of cooling-coil leaving temperature
      8) HCETavg = rolling average of heating-coil entering temperature
      9) HCLTavg = rolling average of heating-coil leaving temperature
   b. %OA = actual outdoor air fraction as a percentage = (MAT – RAT)/(OAT – RAT), or per airflow measurement station if available.
   c. %OAmin = active minimum OA setpoint (MinOAsp) divided by actual total airflow (from sum of VAV box flows or by airflow measurement station) as a percentage.
   d. OS = number of changes in operating state during the previous 60 minutes (moving window)

5. The internal variables shown in Table 5.16.14.5 shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as shown.

Default values are derived from NISTIR 7365 and have been validated in field trials. They are expected to be appropriate for most circumstances, but individual installations may benefit from tuning to improve sensitivity and reduce false alarms.
The default values have been intentionally biased toward minimizing false alarms—if necessary, at the expense of missing real alarms. This avoids excessive false alarms that will erode user confidence and responsiveness. However, if the goal is to achieve the best possible energy performance and system operation, these values should be adjusted based on field measurement and operational experience.
Values for physical factors, such as fan heat, duct heat gain, and sensor error, can be measured in the field or derived from trend logs. Likewise, the occupancy delay and switch delays can be refined by observing in trend data the time required to achieve quasi steady-state operation.
Other factors can be tuned by observing false positives and false negatives (i.e., unreported faults). If transient conditions or noise cause false errors, increase the

alarm delay. Likewise, failure to report real faults can be addressed by adjusting the heating coil, cooling coil, temperature, or flow thresholds.

Table 5 VAV AHU AFDD Internal Variables

Variable Name	Description	Default Value
ΔTSF	Temperature rise across supply fan	1°C (2°F)
ΔTMIN	Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)	6°C (10° F)
ℰSAT	Temperature error threshold for SAT sensor	1°C (2°F)
ℰRAT	Temperature error threshold for RAT sensor	1°C (2°F)
ℰMAT	Temperature error threshold for MAT sensor	3°C (5°F)
ℰOAT	Temperature error threshold for OAT sensor	1°C (2°F) if local sensor @ unit. 3°C (5°F) if global sensor.
ℰF	Airflow error threshold	30%
ℰVFDSPD	VFD speed error threshold	5%
ℰDSP	Duct static pressure error threshold	25 Pa (0.1”)
ℰCCET	Cooling coil entering temperature sensor error. Equal to ℰMAT or dedicated sensor error	Varies, see Description
ℰCCLT	Cooling coil leaving temperature sensor error. Equal to ℰSAT or dedicated sensor error	
ℰHCET	Heating coil entering temperature sensor error; equal to ℰMAT or dedicated sensor error	
ℰHCLT	Heating coil leaving temperature sensor error. Equal to ℰSAT or dedicated sensor error	
ΔOSMAX	Maximum number of changes in Operating State during the previous 60 minutes (moving window)	7
ModeDelay	Time in minutes to suspend Fault Condition evaluation after a change in Mode	30
AlarmDelay	Time in minutes to that a Fault Condition must persist before triggering an alarm	30
TestModeDelay	Time in minutes that Test Mode is enabled	120

The purpose of ΔTmin is to ensure that the mixing box/economizer damper tests are meaningful. These tests are based on the relationship between supply, return, and

outdoor air. If RAT ~ MAT, these tests will not be accurate and will produce false alarms.
The purpose of TestModeDelay is to ensure that normal fault reporting occurs after the testing and commissioning process is completed as prescribed in Section 12.

6. Table 6 shows potential fault conditions that can be evaluated by the AFDD routines. If the equation statement is true, then the specified fault condition exists. The fault conditions to be evaluated at any given time will depend on the OS of the AHU.

The equations in Table 6 assume that the SAT sensor is located downstream of the supply fan and the RAT sensor is located downstream of the return fan. If actual sensor locations differ from these assumptions, it may be necessary to add or delete fan heat correction factors.
To detect the required economizer faults in California Title 24 section 120.2(i)7, use FC#2, #3, and #5 through #13 at a minimum. Other Title 24 AFDD requirements, including acceptance tests, are not met through these fault conditions.

Table 6 VAV AHU Fault Conditions

FC#1	Equation	DSPAVG < DSPSP - ƐDSP and VFDSPD ≥ 99% - ƐVFDSPD	Applies to OS #1 – #5
	Description	Duct static pressure is too low with fan at full speed	
	Possible Diagnosis	Problem with VFD Mechanical problem with fan Fan undersized SAT Setpoint too high (too much zone demand)	
FC#2 (omit if no MAT sensor)	Equation	MATAVG + ƐMAT < min[(RATAVG - ƐRAT), (OATAVG - ƐOAT)]	Applies to OS #1 – #5
	Description	MAT too low; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC#3 (omit if no MAT sensor)	Equation	MATAVG - ƐMAT > max[(RATAVG + ƐRAT), (OATAVG + ƐOAT)]	Applies to OS #1 – #5
	Description	MAT too high; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC#4	Equation	ΔOS > ΔOSMAX	Applies to OS #1 – #5
	Description	Too many changes in Operating State	
	Possible Diagnosis	Unstable control due to poorly tuned loop or mechanical problem	

FC#5 (omit if no MAT sensor)	Equation	SATAVG + ƐSAT ≤ MATAVG - ƐMAT + ΔTSF	Applies to OS #1
	Description	SAT too low; should be higher than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable Gas or electric heat unavailable DX cooling stuck on	
FC#6	Equation	| RATAVG - OATAVG | ≥ ΔTMIN and | %OA - %OAMIN | > ƐF	Applies to OS #1, #4
	Description	OA fraction is too low or too high; should equal %OAMIN	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC#7 (omit if no heating coil)	Equation	SATAVG < SATSP - ƐSAT and HC ≥ 99%	Applies to OS #1
	Description	SAT too low in full heating	
	Possible Diagnosis	SAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable Gas or electric heat unavailable DX cooling stuck on Leaking or stuck economizer damper or actuator	
FC#8 (omit if no MAT sensor)	Equation	$\lvert SATAVG - \Delta TSF - MATAVG \rvert > \sqrt{\varepsilon_{SAT}{}^2 + \varepsilon_{MAT}{}^2}$	Applies to OS #2
	Description	SAT and MAT should be approximately equal	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open Heating coil valve leaking or stuck open	

FC#9	Equation	OATAVG - ƐOAT > SATSP - ΔTSF + ƐSAT	Applies to OS #2
	Description	OAT is too high for free cooling without additional mechanical cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Cooling coil valve leaking or stuck open	
FC#10 (omit if no MAT sensor)	Equation	$\lvert MATAVG - OATAVG \rvert > \sqrt{\varepsilon_{MAT}{}^2 + \varepsilon_{OAT}{}^2}$	Applies to OS #3
	Description	OAT and MAT should be approximately equal	
	Possible Diagnosis	MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC#11	Equation	OATAVG + ƐOAT < SATSP - ΔTSF - ƐSAT	Applies to OS #3
	Description	OAT is too low for mechanical cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Heating coil valve leaking or stuck open Leaking or stuck economizer damper or actuator	
FC#12 (omit if no MAT sensor)	Equation	SATAVG - ƐSAT - ΔTSF ≥ MATAVG + ƐMAT	Applies to OS #2 – #4
	Description	SAT too high; should be less than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too high or CHW unavailable DX cooling unavailable Gas or electric heat stuck on Heating coil valve leaking or stuck open	
FC#13	Equation	SATAVG > SATSP + ƐSAT and CC ≥ 99%	Applies to OS #3, #4
	Description	SAT too high in full cooling	
	Possible Diagnosis	SAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too high or CHW unavailable DX cooling unavailable Gas or electric heat stuck on Heating coil valve leaking or stuck open	

FC#14	Equation	CCETAVG - CCLTAVG ≥ $\sqrt{\varepsilon_{CCET}{}^2 + \varepsilon_{CCLT}{}^2}$ + ΔTSF* *Fan heat factor included or not depending on location of sensors used for CCET and CCLT	Applies to OS #1, #2
	Description	Temperature drop across inactive cooling coil	
	Possible Diagnosis	CCET sensor error CCLT sensor error Cooling coil valve stuck open or leaking DX cooling stuck on	
FC#15	Equation	HCLTAVG - HCETAVG ≥ $\sqrt{\varepsilon_{HCET}{}^2 + \varepsilon_{HCLT}{}^2}$ + ΔTSF* *Fan heat factor included or not depending on location of sensors used for HCET and HCLT	Applies to OS #2 – #4
	Description	Temperature rise across inactive heating coil	
	Possible Diagnosis	HCET sensor error HCLT sensor error Heating coil valve stuck open or leaking.	

7. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the OS of the AHU:
   a. In OS#1 (heating), the following fault conditions shall be evaluated:
      1) FC#1: DSP too low with fan at full speed
      2) FC#2: MAT too low; should be between RAT and OAT
      3) FC#3: MAT too high; should be between RAT and OAT
      4) FC#4: Too many changes in OS
      5) FC#5: SAT too low; should be higher than MAT
      6) FC#6: OA fraction too low or too high; should equal %OAmin
      7) FC#7: SAT too low in full heating
      8) FC#14: Temperature drop across inactive cooling coil
   b. In OS#2 (modulating economizer), the following fault conditions shall be evaluated:
      1) FC#1: DSP too low with fan at full speed
      2) FC#2: MAT too low; should be between RAT and OAT
      3) FC#3: MAT too high; should be between RAT and OAT
      4) FC#4: Too many changes in OS
      5) FC#8: SAT and MAT should be approximately equal
      6) FC#9: OAT too high for free cooling without mechanical cooling
      7) FC#12: SAT too high; should be less than MAT
      8) FC#14: Temperature drop across inactive cooling coil
      9) FC#15: Temperature rise across inactive heating coil
   c. In OS#3 (mechanical + 100% economizer cooling), the following fault conditions shall be evaluated:
      1) FC#1: DSP too low with fan at full speed
      2) FC#2: MAT too low; should be between RAT and OAT
      3) FC#3: MAT too high; should be between RAT and OAT
      4) FC#4: Too many changes in OS
      5) FC#10: OAT and MAT should be approximately equal

6) FC#11: OAT too low for mechanical cooling
7) FC#12: SAT too high; should be less than MAT
8) FC#13: SAT too high in full cooling
9) FC#15: Temperature rise across inactive heating coil

d. In OS#4 (mechanical Cooling, minimum OA), the following fault conditions shall be evaluated:
1) FC#1: DSP too low with fan at full speed
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in OS
5) FC#6: OA fraction too low or too high; should equal %OAmin
6) FC#12: SAT too high; should be less than MAT
7) FC#13: SAT too high in full cooling
8) FC#15: Temperature rise across inactive heating coil

e. In OS#5 (other), the following fault conditions shall be evaluated:
1) FC#1: DSP too low with fan at full speed
2) FC#2: MAT too low; should be between RAT and OAT
3) FC#3: MAT too high; should be between RAT and OAT
4) FC#4: Too many changes in OS

8. For each air handler, the operator shall be able to suppress the alarm for any fault condition.

9. Evaluation of fault conditions shall be suspended under the following conditions:
a. When AHU is not operating
b. For a period of ModeDelay minutes following a change in mode (e.g., from Warmup Mode to Occupied Mode) of any Zone Group served by the AHU

10. Fault conditions that are not applicable to the current OS shall not be evaluated.

11. A fault condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

12. Test mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system, and ensure normal fault detection occurs after testing is complete.

13. When a fault condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from the table in Section 6.

H. Testing/Commissioning Overrides. Provide software switches that interlock to a CHW and hot-water plant level to
a. force HW valve full open if there is a hot-water coil,
b. force HW valve full closed if there is a hot-water coil,
c. force CHW valve full open, and
d. force CHW valve full closed.

Per Section 3.1L, all hardware points can be overridden through the BAS. Each of the following points is interlocked so that they can be overridden together at a zone-group level, per Section 3.4E.

For example, the CxA can check for leaking dampers by forcing all VAV boxes in a Zone Group closed and then recording airflow at the AHU.

I. Plant Requests

1. Chilled-Water Reset Requests
   a. If the supply air temperature exceeds the supply air temperature setpoint by 3°C (5°F) for 2 minutes, send 3 requests.
   b. Else if the supply air temperature exceeds the supply air temperature setpoint by 2°C (3°F) for 2 minutes, send 2 requests.
   c. Else if the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 85%.
   d. Else if the CHW valve position is less than 95%, send 0 requests.

2. Chiller Plant Requests. Send the chiller plant that serves the system a chiller plant request as follows:
   a. If the CHW valve position is greater than 95%, send 1 request until the CHW valve position is less than 10%.
   b. Else if the CHW valve position is less than 95%, send 0 requests.

3. Hot-Water Reset Requests
   a. If the supply air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 requests.
   b. Else if the supply air temperature is 8°C (15°F) less than setpoint for 5 minutes, send 2 requests.
   c. Else if HW valve position is greater than 95%, send 1 request until the HW valve position is less than 85%.
   d. Else if the HW valve position is less than 95%, send 0 requests.

4. Heating Hot Water Plant Requests. Send the heating hot-water plant that serves the AHU a heating hot-water plant request as follows:
   a. If the HW valve position is greater than 95%, send 1 request until the HW valve position is less than 10%.
   b. Else if the HW valve position is less than 95%, send 0 requests.

3.9 SINGLE-ZONE VAV AIR-HANDLING UNIT (AC-1)

A. See “Generic Thermal Zones” (Section 3.2C) for setpoints, loops, control modes, alarms, etc.

B. See Section 1.2G.1 for Cool_SAT, Heat_SAT, and MaxDPT.

C. See Section 1.3C for speed setpoints.

D. Supply Fan Speed Control and Supply Air Temperature Set-Point Reset

These sequences use two supply air temperature setpoints SATsp and SATsp-C that are reset at different rates but are controlled using the same sensor and control loop, as well as a supply-fan speed reset that varies depending on outdoor air temperature. The goal of this scheme is to maximize free cooling and avoid chiller use when the outdoor air is cool, while avoiding excessive fan energy use and using the cooling coil when outdoor air is warm.

For this to work, it is essential that both SATsp and SATsp-C are controlled off the same physical SAT sensor.
It is also critical that the minimum value of the setpoint that controls the economizer SATsp is lower than the minimum value of the setpoint that controls the CHW valve SATsp-C. Otherwise, a brief temperature excursion due to the cooling coil will lead to short cycling of the economizer and subsequent unnecessary energy use by the cooling coil.

1. The supply fan shall run whenever the unit is in any mode other than Unoccupied Mode.

2. Provide a ramp function to prevent changes in fan speed of more than 10% per minute.

3. Minimum, medium, and maximum fan speeds shall be as follows:
   a. Minimum speed MinSpeed, maximum cooling speed MaxCoolSpeed, and maximum heating speed MaxHeatSpeed shall be determined per Section 1.3A.
   b. Medium fan speed MedSpeed shall be reset linearly based on outdoor air temperature from MinSpeed when outdoor air temperature is greater or equal to Endpoint #1 to MaxCoolSpeed when outdoor air temperature is less than or equal to Endpoint #2.
      1) Endpoint #1: the lesser of zone temperature +0.5°C (1°F) and maximum supply air dew point MaxDPT.
      2) Endpoint #2: the lesser of zone temperature minus 6°C (10°F) and the maximum supply air dew point MaxDPT minus 1°C (2°F).

When outdoor air temperature is high, there is a potential for a high humidity ratio, and thus high space humidity, which can increase the risk of mold/mildew. Because dew point sensors are expensive and can quickly drift out of calibration, this sequence uses outdoor air dry-bulb temperature as a proxy for supply air dew point. When outdoor air temperature is above the maximum limit MaxDPT, the medium speed setpoint is kept at the minimum, which will reduce supply air temperature and thus lower supply air temperature setpoint.

4. Minimum and maximum supply air temperature setpoints shall be as follows:
   a. The Deadband values of SATsp and SATsp-C shall be the average of the zone heating setpoint and the zone cooling setpoint but shall be no lower than 21°C (70°F) and no higher than 24°C (75°F).

The deadband setpoint is intended to provide neutral temperature air when the Zone State is deadband. The values of this setpoint are limited to avoid the situation where an extreme value for zone temperature setpoint forces unnecessary heating or cooling, e.g., a cold-aisle setpoint of 32°C (90°F) in a datacenter could cause unnecessary heating if this limit were not in place.

5. When the supply fan is proven on, fan speed and supply air temperature setpoints are controlled as shown in Figures 5.18.4.5-1 through 5.18.4.5-3. The points of transition along the x-axis shown and described are representative. Separate gains shall be provided for each section of the control map, that are determined by the contractor to provide stable control. Alternatively, the

contractor shall adjust the precise value of the x-axis thresholds shown in Figure 5.18.4.5-1 to provide stable control.

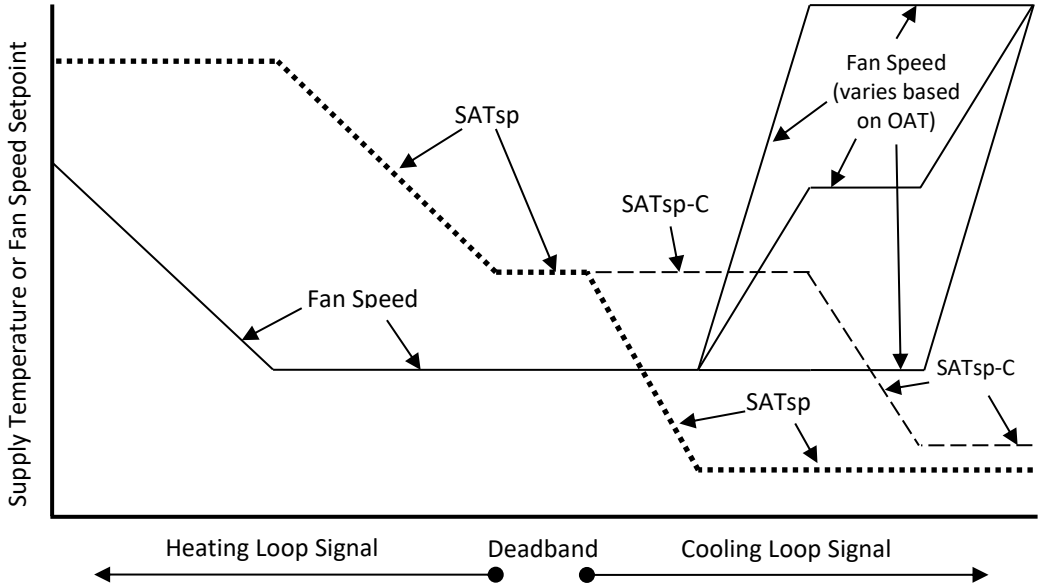


Figure 5.18.4.5-1 Control diagram for SZVAV AHU.

6. Figure 5.18.4.5-2 separates Figure 5.18.4.5-1 in two for clarity and to illustrate the relative setpoints. However, both fan speed and supply air temperature setpoints are reset simultaneously and by the same signal: the value of the Heating Loop or Cooling Loop.
   a. For a heating-loop signal of 100% to 50%, fan speed is reset from MaxHeatSpeed to MinSpeed.
   b. For a heating-loop signal of 50% to 0%, fan speed setpoint is MinSpeed.
   c. In deadband, fan speed setpoint is MinSpeed.
   d. For a cooling-loop signal of 0% to 25%, fan speed is MinSpeed.
   e. For a cooling-loop signal of 25% to 50%, fan speed is reset from MinSpeed to MedSpeed.
   f. For a cooling-loop signal of 50% to 75%, fan speed is MedSpeed.
   g. For a cooling-loop signal of 75% to 100%, fan speed is reset from MedSpeed to MaxCoolSpeed.
   h. For a heating-loop signal of 100% to 50%, SATsp is Heat_SAT.
   i. For a heating-loop signal of 50% to 0%, SATsp is reset from Heat_SAT to the deadband value.
   j. In deadband, SATsp is the deadband value.
   k. For a cooling-loop signal of 0% to 25%, SATsp is reset from the deadband value to Cool_SAT minus 1°C (2°F), while SATsp-C is the deadband value.
   l. For a cooling-loop signal of 25% to 50%, SATsp and SATsp-C are unchanged.
   m. For a cooling-loop signal of 50% to 75%, SATsp remains at Cool_SAT minus 1°C (2°F), SATsp-C is reset from the deadband value to Cool_SAT.
   n. For a cooling-loop signal of 75% to 100%, SATsp and SATsp-C are unchanged.

In cooling, the economizer is controlled to a lower setpoint than the cooling coil (i.e., SATsp < SATsp-C) so that a low-temperature excursion does not cause the economizer to close inadvertently while cooling with mechanical cooling.

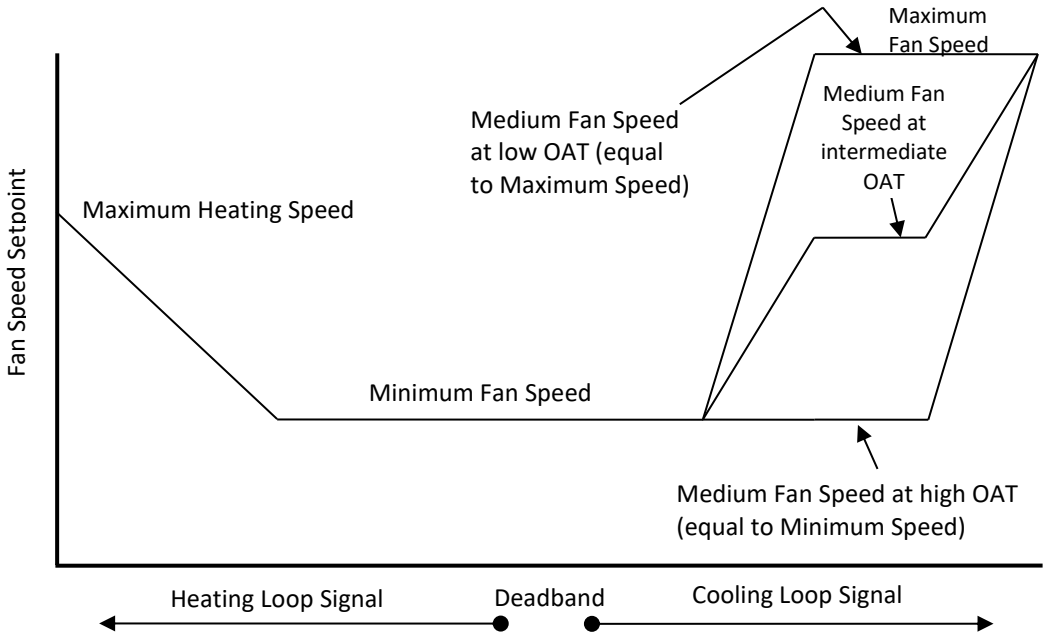


Figure 5.18.4.5-2 Control diagram for SZVAV AHU—fan speed.

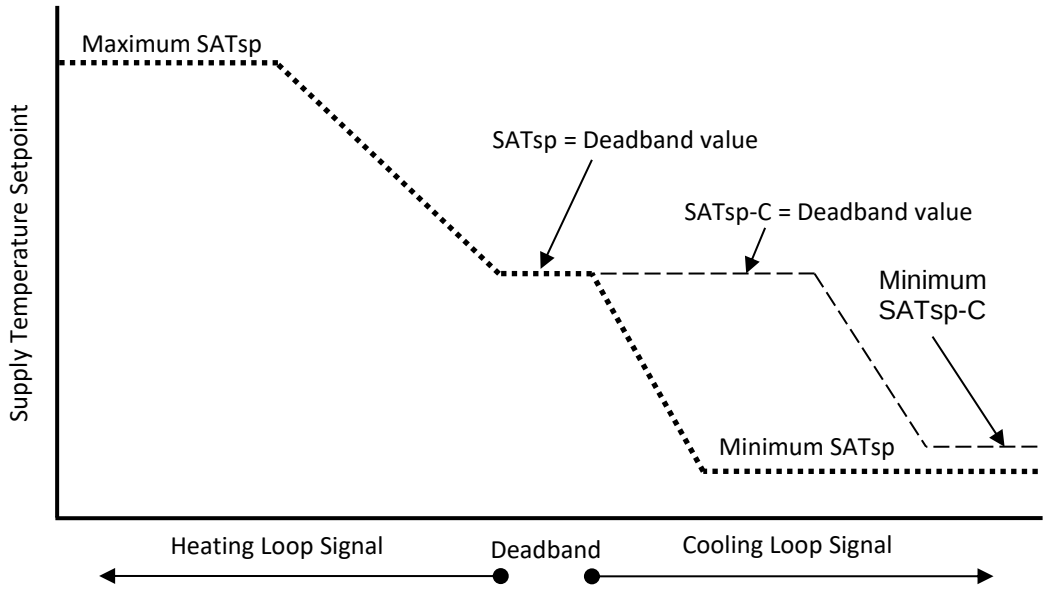


Figure 5.18.4.5-3 Control diagram for SZVAV AHU—supply air temperature.

E. Supply Air Temperature Control

1. There are two supply air temperature setpoints, SATsp and SATsp-C. Each setpoint is maintained by a separate control loop, but both loops use the same supply air temperature sensor.

2. The control loop for SATsp is enabled when the supply air fan is proven on and disabled and set to neutral otherwise.

a. Supply air temperature shall be controlled to SATsp by a control loop whose output is mapped to sequence the heating coil (if applicable) and economizer dampers as shown in the Figure 5.18.5.2. Outdoor air damper minimum MinOA-P and maximum MaxOA-P positions are limited for economizer lockout and to maintain minimum outdoor airflow rate as described in Sections 3.9E.3.band 3.9F.2.

These sequences assume that the heat source can be modulated and thus control SAT to a setpoint in heating. If this is not the case (e.g., because heating is by multistage furnace or electric coil), then the following will need to be modified to add appropriate staging logic.

b. The points of transition along the x-axis shown in Figure 5.18.5.2 are representative. Separate gains shall be provided for each section of the control map (heating coil, economizer) that are determined by the contractor to provide stable control. Alternatively, the contractor shall adjust the precise value of the x-axis thresholds shown in Figure 5.18.5.2 to provide stable control.

Dampers are complementary (rather than sequenced, as they are for multiple-zone VAV AHUs) to reduce equipment costs (avoiding multiple actuators) and to maintain a more-linear relationship between fan speed and outdoor air volume.
In order to make this relationship as linear as possible, the economizer should use parallel blade dampers.

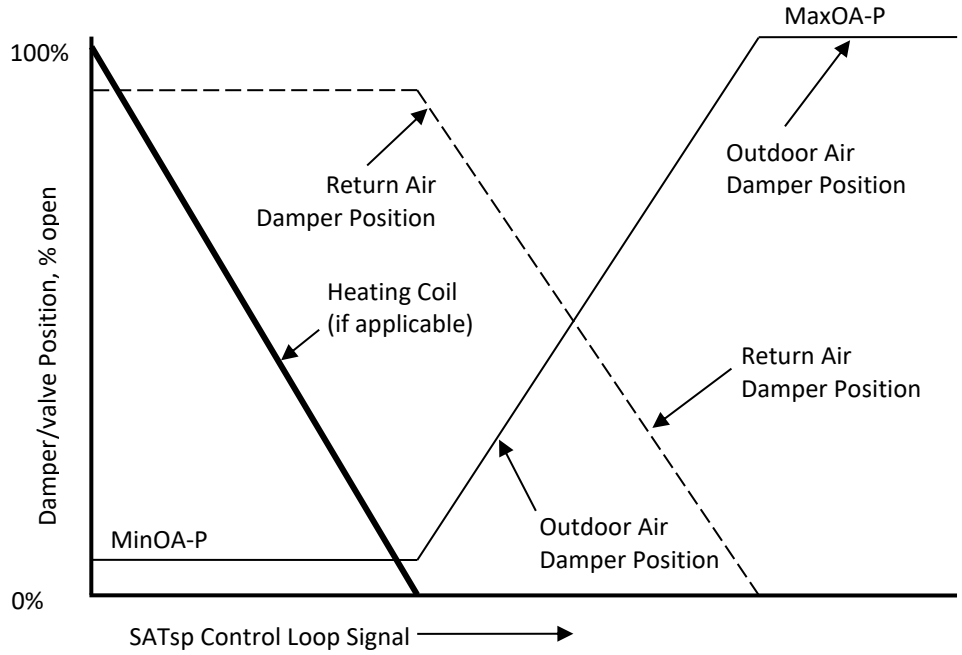


Figure 5.18.5.2 SZVAV AHU supply air temperature loop mapping.

3. The control loop for SATsp-C is enabled when the supply fan is proven on and the Zone State is cooling and disabled and set to neutral otherwise. When enabled, supply air temperature shall be controlled to SATsp-C by modulating the cooling coil with loop output ranging from 0% to 100%.
   a. When the loop is above 50% until it drops to 0%, enable Cool Stage 1.

b. When the loop reaches 100% until it drops to 50%, enable Cool Stage 2.

F. Minimum Outdoor Air Control

1. See Section 3.2 for calculation of zone minimum outdoor airflow setpoint.

2. Outdoor Air Damper Control for Units with an Outdoor Airflow Measurement Station

This section describes minimum outdoor air control logic for a unit with a single common minimum OA and economizer damper (i.e., no separate minimum OA damper) and Demand Control Ventilation.
This logic assumes that there is an airflow measurement station across the outdoor air intake and controls OA volume directly via control over the minimum OA damper position.
Other configurations are possible and would require modifications to the points list (above) and the control logic below.

a. Minimum outdoor air control loop is enabled when the supply fan is proven on and in Occupied Mode and disabled and output set to zero otherwise.
b. The minimum outdoor airflow rate shall be maintained at the minimum outdoor air setpoint MinOAsp by a reverse-acting control loop whose output is mapped to MinOA-P.

G. Economizer Lockout

This section describes economizer lockout logic for a unit with a common minimum OA and economizer damper (i.e., no separate minimum OA damper). Other configurations are possible, and would require modifications to the points list (above) and the control logic below.

1. The normal sequencing of the economizer dampers shall be disabled in accordance with Section 3.1Q.

2. Once the economizer is disabled, it shall not be reenabled within 10 minutes and vice versa.

3. When economizer is enabled, MaxOA-P = 100%. When economizer is disabled, set MaxOA-P equal to MinOA-P. See Section 3.9E, “Supply Air Temperature Control,” and Section 3.9E.3.b, “Minimum Outdoor Air Control,” for outdoor air damper minimum setpoint.

H. Return-Fan Control

1. Return fan operates whenever the associated supply fan is proven on and shall be off otherwise.

2. Building static pressure shall be time averaged with a sliding 5-minute window and 15 second sampling rate (to dampen fluctuations). The averaged value shall be that displayed and used for control.

3. Return fan shall be controlled to maintain building static pressure at setpoint of 0.05”.

I. Alarms

1. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
   a. Commanded on, status off: Level 2
   b. Commanded off, status on: Level 4

J. Automatic Fault Detection and Diagnostics

The AFDD routines for AHUs continually assess AHU performance by comparing the values of BAS inputs and outputs to a subset of potential fault conditions. The subset of potential fault conditions that is assessed at any point depends on the OS of the AHU, as determined by the position of the cooling and heating valves and the economizer damper. Time delays are applied to the evaluation and reporting of fault conditions to suppress false alarms. Fault conditions that pass these filters are reported to the building operator along with a series of possible causes.
These equations assume that the air handler is equipped with hydronic heating and cooling coils, as well as a fully integrated economizer. If any of these components are not present, the associated tests and variables should be omitted from the programming.
Note that these alarms rely on reasonably accurate measurement of mixed air temperature. An MAT sensor is required for many of these alarms to work, and an averaging sensor is strongly recommended for best accuracy. If an MAT sensor is not installed, omit Fault Conditions #2, #3, #5, #8, #10, and #12. If a heating coil is not installed, omit Fault Condition #7.

1. AFDD conditions are evaluated continuously and separately for each operating AHU.

2. The OS of each AHU shall be defined by the commanded positions of the heating-coil control valve, cooling-coil control valve, and economizer damper in accordance with Table 5.18.13.2 and Figure 5.18.13.2.

Table 5.18.13.2 SZVAV AHU Operating States

Operating State	Heating Valve Position	Cooling Valve Position	Outdoor Air Damper Position
#1: Heating	> 0	= 0	= MinOA-P
#2: Free cooling, modulating OA	= 0	= 0	MinOA-P < x < 100%
#3: Mechanical + economizer cooling	= 0	> 0	= 100%
#4: Mechanical cooling, minimum OA	= 0	> 0	= MinOA-P
#5: Unknown or dehumidification	No other OS applies		

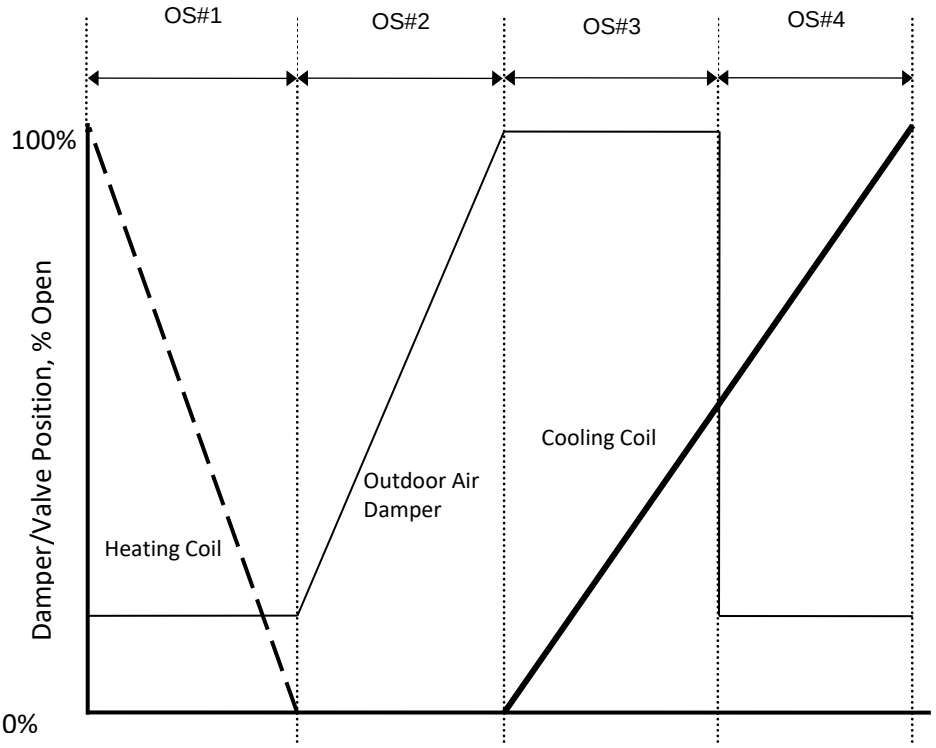


Figure 5.18.13.2 SZVAV AHU operating states.

The OS is distinct from, and should not be confused with, the zone status (cooling, heating, deadband) or Zone Group mode (occupied, warmup, etc.).
OS#1 through OS#4 (see Table 5.18.13.2) represent normal operation during which a fault may nevertheless occur if so determined by the fault condition tests in Section 3.9J.6. By contrast, OS#5 may represent an abnormal or incorrect condition (such as simultaneous heating and cooling) arising from a controller failure or programming error, but it may also occur normally, e.g., when dehumidification is active or during warmup.

3. The following points must be available to the AFDD routines for each AHU:

For the AFDD routines to be effective, an averaging sensor is recommended for supply air temperature. An averaging sensor is essential for mixed air temperature, as the environment of the mixing box will be subject to nonuniform and fluctuating air temperatures. It is recommended that the OAT sensor be located at the AHU so that it accurately represents the temperature of the incoming air.

   a. SAT = supply air temperature
   b. MAT = mixed air temperature
   c. RAT = return air temperature
   d. OAT = outdoor air temperature
   e. DSP = duct static pressure
   f. SATsp = supply air temperature setpoint for heating coil and economizer control
   g. SATsp-C = supply air temperature setpoint for cooling coil control
   h. HC = heating-coil valve position command; 0% □ HC □ 100%

i. CC = cooling-coil valve position command; 0% □ CC □ 100%
j. FS = fan-speed command; 0% □ FS □ 100%
k. CCET = cooling-coil entering temperature (Depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose).
l. CCLT = cooling-coil leaving temperature (Depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.)
m. HCET = heating-coil entering temperature (Depending on the AHU configuration, this could be the MAT or a separate sensor for this specific purpose.)
n. HCLT = heating-coil leaving temperature (Depending on the AHU configuration, this could be the SAT or a separate sensor for this specific purpose.)

4. The following values must be continuously calculated by the AFDD routines for each AHU:
   a. Five-minute rolling averages with 1-minute sampling of the following point values; operator shall have the ability to adjust the averaging window and sampling period for each point independently.
      1) SATavg = rolling average of supply air temperature
      2) MATavg = rolling average of mixed air temperature
      3) RATavg = rolling average of return air temperature
      4) OATavg = rolling average of outdoor air temperature
      5) CCETavg = rolling average of cooling-coil entering temperature
      6) CCLTavg = rolling average of cooling-coil leaving temperature
      7) HCETavg = rolling average of heating-coil entering temperature
      8) HCLTavg = rolling average of heating-coil leaving temperature
      9) □OS = number of changes in OS during the previous 60 minutes (moving window)

5. The internal variables shown in Table 5.18.13.5 shall be defined for each AHU. All parameters are adjustable by the operator, with initial values as given below.

Default values are derived from NISTIR 7365 and have been validated in field trials. They are expected to be appropriate for most circumstances, but individual installations may benefit from tuning to improve sensitivity and reduce false alarms.
The default values have been intentionally biased toward minimizing false alarms, if necessary at the expense of missing real alarms. This avoids excessive false alarms that will erode user confidence and responsiveness. However, if the goal is to achieve the best possible energy performance and system operation, these values should be adjusted based on field measurement and operational experience.
Values for physical factors such as fan heat, duct heat gain, and sensor error can be measured in the field or derived from trend logs. Likewise, the occupancy delay and switch delays can be refined by observing in trend data the time required to achieve quasi steady state operation.
Other factors can be tuned by observing false positives and false negatives (i.e., unreported faults). If transient conditions or noise cause false errors, increase the alarm delay. Likewise, failure to report real faults can be addressed by adjusting the heating coil, cooling coil, temperature, or flow thresholds.

Table 5.18.13.5 SZVAV AHU Internal Variables

Variable Name	Description	Default Value
ΔTSF	Temperature rise across supply fan	0.5°C (1°F)
ΔTMIN	Minimum difference between OAT and RAT to evaluate economizer error conditions (FC#6)	6°C (10°F)
□SAT	Temperature error threshold for SAT sensor	1°C (2°F)
□RAT	Temperature error threshold for RAT sensor	1°C (2°F)
□MAT	Temperature error threshold for MAT sensor	3°C (5°F)
□OAT	Temperature error threshold for OAT sensor	1°C (2°F) if local sensor @ unit. 3°C (5°F) if global sensor.
□CCET	Cooling coil entering temperature sensor error. Equal to □MAT or dedicated sensor error	Varies; see description.
□CCLT	Cooling coil leaving temperature sensor error. Equal to □SAT or dedicated sensor error	
□HCET	Heating coil entering temperature sensor error; equal to □MAT or dedicated sensor error	
□HCLT	Heating coil leaving temperature sensor error. Equal to □SAT or dedicated sensor error	
□OSmax	Maximum number of changes in Operating State during the previous 60 minutes (moving window)	7
ModeDelay	Time in minutes to suspend Fault Condition evaluation after a change in mode	30
AlarmDelay	Time in minutes that a Fault Condition must persist before triggering an alarm	30
TestModeDelay	Time in minutes that Test Mode is enabled	120

The purpose of □Tmin is to ensure that the mixing box/economizer damper tests are meaningful. These tests are based on the relationship between supply, return, and outdoor air. If RAT □ MAT, these tests will not be accurate and will produce false alarms.
The purpose of TestModeDelay is to ensure that normal fault reporting occurs after the testing and commissioning process is completed as described in Section 3.9J.12.

6. Table 5.18.13.6 shows potential fault conditions that can be evaluated by the AFDD routines. (At most, 14 of the 15 fault conditions are actively evaluated, but numbering was carried over from multiple-zone AHUs for consistency.) If the equation statement is true, then the specified fault condition exists. The fault conditions to be evaluated at any given time will depend on the OS of the AHU.

The equations in Table 5.18.13.6 assume that the SAT sensor is located downstream of the supply fan and the RAT sensor is located downstream of the return fan. If actual sensor locations differ from these assumptions, it may be necessary to add or delete fan heat correction factors.
To detect the required economizer faults in California Title 24 section 120.2(i)7, use FC#2, #3, and #5 through #13 at a minimum. Other Title 24 AFDD requirements, including acceptance tests, are not met through these fault conditions.

Table 5.18.13.6 SZVAV AHU Fault Conditions

FC #1	This fault condition is not used in single zone units, as it requires a static pressure setpoint.		Applies to OS #1 – #5
FC #2 (omit if no MAT sensor)	Equation	MATAVG + ƐMAT < min[(RATAVG - ƐRAT), (OATAVG - ƐOAT)]	Applies to OS #1 – #5
	Description	MAT too low; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC #3 (omit if no MAT sensor)	Equation	MATAVG - ƐMAT > min[(RATAVG + ƐRAT), (OATAVG + ƐOAT)]	Applies to OS #1 – #5
	Description	MAT too high; should be between OAT and RAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error	
FC #4	Equation	ΔOS > ΔOSMAX	Applies to OS #1 – #5
	Description	Too many changes in Operating State	
	Possible Diagnosis	Unstable control due to poorly tuned loop or mechanical problem	

FC #5 (omit if no MAT sensor)	Equation	SATAVG + ℰSAT ≤ MATAVG - ℰMAT + ΔTSF	Applies to OS #1
	Description	SAT too low; should be higher than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable Gas or electric heat unavailable	
FC #6	Equation	| RATAVG - OATAVG | ≥ ΔTMIN and | RATAVG - MATAVG | > | OATAVG - MATAVG |	Applies to OS #1, #4
	Description	OA fraction is too high; MAT should be closer to RAT than to OAT	
	Possible Diagnosis	RAT sensor error MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC #7 (omit if no heating coil)	Equation	SATAVG < SATSP - ℰSAT and HC ≥ 99%	Applies to OS #1
	Description	SAT too low in full heating	
	Possible Diagnosis	SAT sensor error Cooling coil valve leaking or stuck open Heating coil valve stuck closed or actuator failure Fouled or undersized heating coil HW temperature too low or HW unavailable Gas or electric heat is unavailable DX cooling is stuck on Leaking or stuck economizer damper or actuator	

FC #8 (omit if no MAT sensor)	Equation	$\lvert SATAVG - \Delta TSF - MATAVG \rvert > \sqrt{\varepsilon_{SAT}{}^2 + \varepsilon_{MAT}{}^2}$	Applies to OS #2
	Description	SAT and MAT should be approximately equal	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve leaking or stuck open DX cooling stuck on Heating coil valve leaking or stuck open Gas or electric heat stuck on	
FC #9	Equation	$OATAVG + \varepsilon OAT > SATSP - \Delta TSF + \varepsilon SAT$	Applies to OS #2
	Description	OAT is too high for free cooling without additional mechanical cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Cooling coil valve leaking or stuck open DX cooling stuck on	
FC #10 (omit if no MAT sensor)	Equation	$\lvert MATAVG - OATAVG \rvert > \sqrt{\varepsilon_{MAT}{}^2 + \varepsilon_{OAT}{}^2}$	Applies to OS #3
	Description	OAT and MAT should be approximately equal	
	Possible Diagnosis	MAT sensor error OAT sensor error Leaking or stuck economizer damper or actuator	
FC #11	Equation	$OATAVG + \varepsilon OAT < SATSP - \Delta TSF - \varepsilon SAT$	Applies to OS #3
	Description	OAT is too low for mechanical cooling	
	Possible Diagnosis	SAT sensor error OAT sensor error Heating coil valve leaking or stuck open Gas or electric heat stuck on Leaking or stuck economizer damper or actuator	

FC #12 (omit if no MAT sensor)	Equation	SATAVG - ℰSAT - ΔTSF ≥ MATAVG + ℰMAT	Applies to OS #2 – #4
	Description	SAT too high; should be less than MAT	
	Possible Diagnosis	SAT sensor error MAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too high or CHW unavailable DX cooling unavailable Gas or electric heat stuck on Heating coil valve leaking or stuck open	
FC #13	Equation	SATAVG > SATSP-C + ℰSAT and CC ≥ 99%	Applies to OS #3, #4
	Description	SAT too high in full cooling	
	Possible Diagnosis	SAT sensor error Cooling coil valve stuck closed or actuator failure Fouled or undersized cooling coil CHW temperature too low or CHW unavailable DX cooling unavailable Gas or electric heat stuck on Heating coil valve leaking or stuck open	
FC#14	Equation	CCETAVG - CCLTAVG ≥ $\sqrt{\varepsilon_{CCET}{}^2 + \varepsilon_{CCLT}{}^2}$ + ΔTSF* *Fan heat factor included or not depending on location of sensors used for CCET and CCLT	Applies to OS #1, #2
	Description	Temperature drop across inactive cooling coil	
	Possible Diagnosis	CCET sensor error CCLT sensor error Cooling coil valve stuck open or leaking DX cooling stuck on	

FC#15	Equation	HCLTAVG - HCETAVG ≥ $\sqrt{\varepsilon_{HCET}{}^2 + \varepsilon_{HCLT}{}^2}$ + ΔTSF* *Fan heat factor included or not depending on location of sensors used for HCET and HCLT	Applies to OS #2 – #4
	Description	Temperature rise across inactive heating coil	
	Possible Diagnosis	HCET sensor error HCLT sensor error Heating coil valve stuck open or leaking Gas or electric heat stuck on	

7. A subset of all potential fault conditions is evaluated by the AFDD routines. The set of applicable fault conditions depends on the OS of the AHU. If an MAT sensor is not installed, omit FCs #2, #3, #5, #8, #10, and #12. If there is no heating coil, omit FC#7:
   a. In OS#1 (Heating), the following fault conditions shall be evaluated:
      1) FC#2: MAT too low; should be between RAT and OAT
      2) FC#3: MAT too high; should be between RAT and OAT
      3) FC#4: Too many changes in OS
      4) FC#5: SAT too low; should be higher than MAT
      5) FC#6: OA fraction too high; MAT should be closer to RAT than to OAT
      6) FC#7: SAT too low in full heating
      7) FC#14: Temperature drop across inactive cooling coil
   b. In OS#2 (modulating economizer), the following fault conditions shall be evaluated:
      1) FC#2: MAT too low; should be between RAT and OAT
      2) FC#3: MAT too high; should be between RAT and OAT
      3) FC#4: Too many changes in OS
      4) FC#8: SAT and MAT should be approximately equal
      5) FC#9: OAT too high for free cooling without mechanical cooling
      6) FC#12: SAT too high; should be less than MAT
      7) FC#14: Temperature drop across inactive cooling coil
      8) FC#15: Temperature rise across inactive heating coil
   c. In OS#3 (mechanical + 100% economizer cooling), the following fault conditions shall be evaluated:
      1) FC#2: MAT too low; should be between RAT and OAT
      2) FC#3: MAT too high; should be between RAT and OAT
      3) FC#4: Too many changes in OS
      4) FC#10: OAT and MAT should be approximately equal
      5) FC#11: OAT too low for mechanical cooling
      6) FC#12: SAT too high; should be less than MAT
      7) FC#13: SAT too high in full cooling
      8) FC#15: Temperature rise across inactive heating coil
   d. In OS#4 (mechanical cooling, minimum OA), the following fault conditions shall be evaluated:

1) FC#2: MAT too low; should be between RAT and OAT
2) FC#3: MAT too high; should be between RAT and OAT
3) FC#4: Too many changes in OS
4) FC#6: OA fraction too high; MAT should be closer to RAT than to OAT
5) FC#12: SAT too high; should be less than MAT
6) FC#13: SAT too high in full cooling
7) FC#15: Temperature rise across inactive heating coil

e. In OS#5 (other), the following fault conditions shall be evaluated:
1) FC#2: MAT too low; should be between RAT and OAT
2) FC#3: MAT too high; should be between RAT and OAT
3) FC#4: Too many changes in OS

8. For each air handler, the operator shall be able to suppress the alarm for any fault condition.

9. Evaluation of fault conditions shall be suspended under the following conditions:
a. When AHU is not operating
b. For a period of ModeDelay minutes following a change in mode (e.g., from Warmup Mode to Occupied Mode) of any Zone Group served by the AHU

10. Fault conditions that are not applicable to the current OS shall not be evaluated.

11. A fault condition that evaluates as true must do so continuously for AlarmDelay minutes before it is reported to the operator.

12. Test mode shall temporarily set ModeDelay and AlarmDelay to 0 minutes for a period of TestModeDelay minutes to allow instant testing of the AFDD system and ensure normal fault detection occurs after testing is complete.

13. When a fault condition is reported to the operator, it shall be a Level 3 alarm and shall include the description of the fault and the list of possible diagnoses from Table 5.18.13.6.

K. Testing/Commissioning Overrides. Provide software switches that interlock to a CHW and hot-water plant level to
a. force HW valve full open if there is a hot-water coil,
b. force HW valve full closed if there is a hot-water coil,
c. force CHW valve full open if there is a CHW coil, and
d. force CHW valve full closed if there is a CHW coil.

Per Section 3.1K, all hardware points can be overridden through the BAS. Each of the following points is interlocked so that they can be overridden as a group on a plant level.
For example, the CxA can check for valve leakage by simultaneously forcing closed all CHW valves at all AHUs served by the chiller plant and then recording flow at the chiller.

L. Plant Requests

1. Hot-Water Reset Requests
a. If the supply air temperature is 17°C (30°F) less than SATsp for 5 minutes, send 3 requests.

b. Else if the supply air temperature is 8°C (15°F) less than SATsp for 5 minutes, send 2 requests.
c. Else if HW valve position is greater than 95%, send 1 request until the HW valve position is less than 85%.
d. Else if the HW valve position is less than 95%, send 0 requests.

2. Heating Hot-Water Plant Requests. Send the heating hot-water plant that serves the AHU a heating hot-water plant request as follows:
a. If the HW valve position is greater than 95%, send 1 request until the HW valve position is less than 10%.
b. Else if the HW valve position is less than 95%, send 0 requests.

3.10 GENERAL CONSTANT SPEED EXHAUST FAN

A. EF-4, 5

1. Exhaust fan shall operate when any of the associated system supply fans is proven on and any associated Zone Group is in the Occupied Mode. See Section 1.2D for Zone Group assignments.

B. EF-8

1. Run 24/7

C. Alarms

1. Maintenance interval alarm when fan has operated for more than 3,000 hours: Level 4. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status being different from the command for a period of 15 seconds.
a. Commanded on, status off: Level 2
b. Commanded off, status off: Level 4

3.11 PACKAGED SINGLE ZONE HEAT PUMP OR AC UNIT WITH DDC (ACS-1, 2)

A. See “Generic Thermal Zones” (Section 3.3) for setpoints, loops, control modes, alarms, etc.

B. Supply fan control

1. The unit fan shall run only when zone is in Cooling State or Heating State and off in Deadband State.

C. Cooling control

1. Cooling is enabled when the zone is in Cooling State.

2. The zone Cooling Loop output shall be mapped to stage the two stages of cooling as follows. Each stage shall have a 5 minute minimum on time and a 5 minute minimum off-time:

a. Stage 1 of cooling shall be enabled when the loop output is at 50 and staged off when the loop output is at 0. Note the economizer (where applicable) is enabled by the unit controls whenever the first stage of cooling is engaged.
b. Stage 2 of cooling shall be enabled when the loop output is at 100 and staged off when the loop output is at 50.
c. Each stage shall have a 5 minute minimum on time and a 5 minute minimum off-time

D. Alarms

1. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status input being different from the output command for 15 seconds.
   a. Commanded on, status off: Level 2. Do not evaluate alarm until the device has been commanded on for 15 seconds.
   b. Commanded off, status on: Level 4. Do not evaluate the alarm until the device has been commanded off for 60 seconds.

3. Generate a Level 3 alarm if:
   a. Cooling outputs are on and supply air fan is proven on and supply air temperature is above 65°F for more than 3 minutes indicating cooling system failure.

3.12 CHILLED WATER PLANT

A. See Section 1.2H and Section 1.3D for setpoints.

B. Plant Enable/Disable

1. The chiller plant shall include an enabling schedule that allows operators to lock out the plant during off-hours, holidays, or any other scheduled event, e.g., to allow off-hour operation of HVAC systems except the chiller plant. The default schedule shall be 24/7 (adjustable).

2. Enable the plant in the lowest stage when the plant has been disabled for at least 15 minutes and:
   a. Number of Chiller Plant Requests > I (I = Ignores shall default to 0, adjustable from graphic), and
   b. OAT>CH-LOT, and
   c. The chiller plant enable schedule is active.

3. Disable the plant when it has been enabled for at least 15 minutes and:
   a. Number of Chiller Plant Requests ≤ I for 3 minutes, or
   b. OAT<CH-LOT – 1°F, or
   c. The chiller plant enable schedule is inactive.

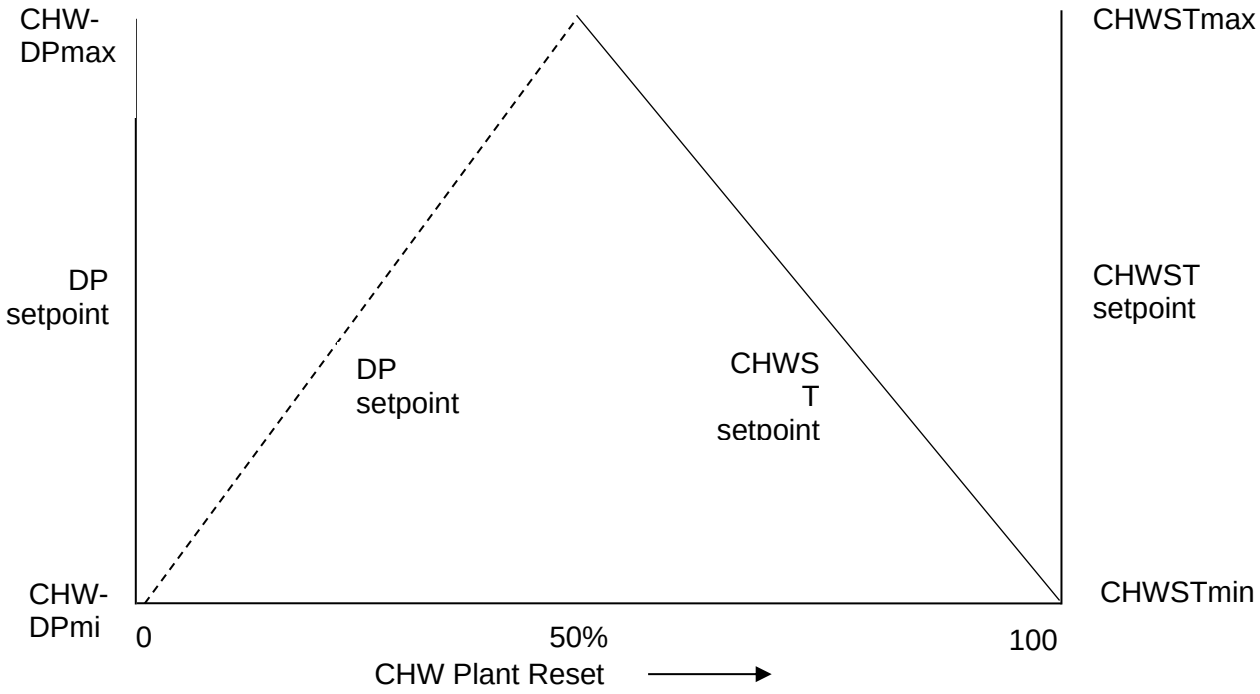
4. When the plant is enabled:
   a. Start CHW pump and CW pump
   b. Enable cooling tower per Paragraph 3.12H.

c. After CHW pump and CW pump are proven on, enable chiller.

5. When the plant is disabled:
   a. Disable chiller.
   b. After two minutes, shut off CHW and CW pumps
   c. Disable the cooling tower per Paragraph 3.12H.

C. Chilled Water Plant Reset

1. Differential Pressure Controlled Loops: Chilled water supply temperature setpoint CHWSTsp and pump differential pressure setpoint CHW-DPsp shall be reset based on the current value of the logic variable called “CHW Plant Reset” as shown below and described subsequently.



The recommended logic first resets differential pressure setpoint to maximum before resetting chilled water supply temperature setpoint down towards design. Parametric plant analysis performed in a variety of climate zones during the development of ASHRAE’s “Fundamentals of Design and Control of Central Chilled-Water Plants” Self-Directed Learning Course showed that the pump energy penalty incurred with this approach is more than offset by chiller energy savings resulting from keeping the chilled water supply temperature setpoint as high as possible.

a. From 0% loop output to 50% loop output, reset DP setpoint from CHW-DPmin to CHWP-DPmax.
b. From 50% loop output to 100% loop output, reset CHWST setpoint from CHWSTmax to CHWSTmin.
c. CHW Plant Reset variable shall be reset using Trim & Respond logic with the following parameters:

Variable	Value

Device	Any CHW Pump Distribution Loop
SP0	100%
SPmin	0%
SPmax	100%
Td	15 minutes
T	5 minutes
I	2
R	Cooling CHWST Reset Requests
SPtrim	-2%
SPres	+3%
SPres-max	+7%

The reset starts at CHWSTmin because starting at a high temperature often causes the chiller to bring down CHWST too quickly and pass the CHWST setpoint, leading the chiller to cycle off. Additionally, if the loop reset starts at a CHWST that cannot satisfy the load at startup (e.g., CHWST setpoint = 60°F, but an AHU requires 55°F supply air), there is a resultant delay in satisfying the load as the reset loop winds up before CHWST setpoint resets down.

d. CHWST Plant Reset loop shall be enabled when the plant is enabled and disabled when the plant is disabled.
e. When a plant stage change is initiated, CHW Plant Reset logic shall be disabled and value fixed at its last value for the longer of 15 minutes and the time it takes for the plant to successfully stage.

Locking out continued reset during a staging event prevents CHW loop instability resulting from staging from driving the plant reset.

D. Chilled Water Pump Speed

1. Remote secondary loop DP shall be maintained at a setpoint of CHW-DPsp determined by the reset scheme described herein. CHW-DPsp shall be maintained by a reverse acting PID loop running in the controller to which the remote sensor is wired; the loop output shall be a DP setpoint for the local plant loop DP sensor hardwired to the plant pump controller. Reset local DP from 5 psi at 0% loop output to LocalCHW-DPmax at 100% loop output.

2. When CHW pump is proven on, pump speed will be controlled by a reverse acting PID loop maintaining the local plant DP signal at the DP setpoint output of the remote sensor control loop.

The above situation arises in very large buildings where it may be impractical to homerun the DP sensor all the way back to the CHW plant.
The above cascading control logic prevents pump speed instability issues that would otherwise be caused by running the pump speed control loop over the BAS network.

It also provides some fault tolerance should the network fail—instead of the loop either winding all the way up or all the way down, DP is controlled to the last known setpoint sent from the remote controller until network communication is restored.

E. Chilled Water Minimum Flow Bypass Valve

1. Bypass valve shall modulate to maintain minimum flow as measured by the chilled water flow meter at a setpoint that provides minimum flow through the operating chiller.

2. When CHW pump is proven on, the bypass valve PID loop shall be enabled. The valve shall be opened 100% otherwise. When enabled, the bypass valve loop shall be biased to start with the valve 100% open.

Biasing the loop to 100% upon start up ensures that the valve does not slam shut upon enabling the loop. Starting with the valve fully open is appropriate because flows are often very low when the plant is first turned on.

F. Head Pressure Control

1. Head pressure control signal shall be that output from the chiller controller whenever available. Otherwise, if a head pressure control signal is not available from the chiller controller, a reverse acting PID loop shall maintain the temperature differential between the chiller's condenser water return temperature and chilled water supply temperature at LIFTminX.

2. Head pressure control loop is enabled when the chiller is enabled. The loop output shall reset maximum cooling tower speed point, HpTowerMaxSpd, from 100% at 0% loop output to minimum speed at 100% loop output.

G. Water Treatment Override

1. Every night at 1:00 am, if all condenser water pumps are off and the condenser water pumps have not accumulated at least 20 minutes of runtime in the last 36 hours then:
   a. Start lead condenser water pump.
   b. After 20 minutes, or if the plant is enabled, release back to normal control.

H. Cooling Tower

1. Fan Control
   a. Condenser Water Return Temperature (CWRT) Control
      1) Tower fan control is in part dictated by plant part load ratio, PLRplant, which is the ratio of current plant required capacity, Qrequired, to plant design capacity, both in tons:

$$PLR_{plant} = \frac{Q_{required}}{Q_{design}}$$

$$Q_{required} = \frac{FLOW_P(CHWRT - CHWST_{SP})}{24}\ [tons]$$

      2) CWRT setpoint, CWRTsp, shall be the output of the following equation.

$$CWRTsp = CHWSTsp + LIFTtarget$$

$$LIFTtarget = Max\big(LIFTmin, Min(LIFTmax, A * PLR_{Plant} + B)\big)$$

$$A = 1.1 * (LIFTmax - LIFTmin)$$

$$B = LIFTmax - A$$

3) When any condenser water pump is proven on, CWRT shall be maintained at setpoint by a direct acting PID loop. The loop output shall be mapped to the variable CWRTTowerSpd. Map CWRTTowerSpd from minimum tower speed at 0% loop output to 100% speed at 100% loop output.
4) Tower speed command signal shall be the lowest value of CWRTTowerSpd, HpTowerMaxSpd from each chiller head pressure control loop, and PlrTowerMaxSpd.
5) Disable the tower fan if either
   a) Any enabled chiller's HpTowerMaxSpd has equaled tower minimum speed for 5 minutes, or
   b) Tower fans have been at minimum speed for 5 minutes and CWRT drops below setpoint minus 1°F.
6) Enable the tower fans if
   a) They have been off for at least 1 minute, and
   b) CWRT rises above setpoint by 1°F, and
   c) Enabled chillers' HpTowerMaxSpd is greater than tower minimum speed.
7) When all condenser water pumps are commanded off, disable the PID loop and stop tower fan.
8) Upon plant startup, hold CWRTsp at 10°F degrees less than CWRTdes for 10 minutes before ramping the setpoint to the calculated value above over 10 minutes.

This logic gives plant load an opportunity to stabilize prior to releasing control to the reset logic.

I. Performance Monitoring

1. All calculations listed below shall be performed at least once every 30 seconds. Time averaged values shall be recorded at least once every 5 minutes. The averaging period shall equal the trending interval.

2. Total plant power. Calculate total plant power as the sum of chiller power, pump power, and cooling tower fan power. For motors with VFDs, power shall be actual power as read through the VFD network interface. For fixed speed motors (e.g., CW pumps without VFDs), power shall be assumed to be fixed at BHP (from equipment schedule) * 0.746 / 0.93 (approximate motor efficiency).

3. Total Plant Load. Calculate plant load using flowrate through the primary circuit, FLOWP; chilled water return temperature upstream of the first HX or chiller, CHWRT; and primary loop chilled water supply temperature leaving the plant, CHWST.

$$Q_{Plant} = \frac{FLOW_P\ (CHWRT - CHWST)}{24}[tons]$$

4. Calculate plant efficiency as total plant power divided by plant load. Calculate efficiency for each chiller as chiller power divided by chiller load.

5. Summary Data. For the total plant, statistics shall be calculated for runtime, kWh, average actual efficiency (kW/ton), peak demand (tons), average demand (tons) and average load (ton-hours), all on an instantaneous, year-to-date, and previous-year basis.

Below is an example summary of the performance monitoring parameters. Summary table should be edited based on plant configuration, available statistics and desired units of measurement.

	Instantaneous				Year-to-date						Previous Year					
	Lifetime Runtime (hours)	Electrical Demand (kW)	CHW Demand (ton)	Efficiency (kW/ton)	Runtime (hours)	Avg Daily Energy Use (kWh)	Avg Daily CHW Load (ton-hr)	Avg CHW Demand (ton)	Peak CHW Demand (ton)	Avg Efficiency (kW/ton)	Runtime (hours)	Avg Daily Energy Use (kWh)	Avg Daily CHW Load (ton-hr)	Avg CHW Demand (ton)	Peak CHW Demand (ton)	A Effic (kW/
CH-1																

J. Alarms

1. Maintenance interval alarm when pump has operated for more than 3000 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.

2. Maintenance interval alarm when chiller has operated for more than 1000 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.

3. Chiller alarm: level 2

4. Emergency off switch: Level 1

5. Pump or tower fan alarm is indicated by the status input being different from the output command for 15 seconds.
   a. Commanded on, status off: Level 2. Do not evaluate alarm until the equipment has been commanded on for 15 seconds.
   b. Commanded off, status on: Level 4. Do not evaluate the alarm until the equipment has been commanded off for 60 seconds.

6. High chiller leaving chilled water temperature (more than 5°F above setpoint) for more than 15 minutes when chiller has been enabled for longer than 15 minutes: Level 3

7. Refrigerant monitor indicates evacuate level alarm: Level 1

8. Refrigerant monitor malfunction or warning level alarm: Level 2

9. Refrigerant caution level alarm: Level 3

10. Excessive CW approach indicating water side fouling: If leaving condenser water temperature is more than 3°F below refrigerant condensing temperature for 15 minutes at least 15 minutes after chiller start: Level 4

11. Excessive CHW approach indicating water side fouling: If leaving chilled water temperature is more than 3°F above refrigerant evaporator temperature for 15 minutes at least 15 minutes after chiller start: Level 4

12. CHW System low gauge pressure
    a. if CHW system gauge pressure falls 1 psig below the scheduled expansion tank pre-charge pressure for 5 minutes, (indicating need to fill): Level 3.
    b. if CHW system gauge pressure falls below 0.9 times the scheduled expansion tank pre-charge pressure for 1 minute, (indicating possible leak): Level 2.

13. Cooling tower
    a. Low level alarm: Level 2
    b. High level alarm: Level 2

K. Automatic Fault Detection and Diagnostics

1. Not Used.

3.13 DOMESTIC & INDUSTRIAL WATER

A. DHW recirculation pump shall operate when AH-3 is in Occupied Mode.

B. IHW recirculation pump shall operate 24/7.

C. Alarms

1. Generate a Level 4 maintenance alarm when pump has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.

2. Pump alarm is indicated by the status input being different from the output command for 15 seconds.
    a. Commanded on, status off: Level 2. Do not evaluate alarm until the device has been commanded on for 15 seconds.
    b. Commanded off, status on: Level 4. Do not evaluate the alarm until the device has been commanded off for 60 seconds.

3. Hot water supply temperature less than setpoint minus 10°F when recirculation pump is proven on: Level 2.

3.14 LABORATORY EXHAUST SYSTEM CONTROL

A. EF-1 and EF-2 lab exhaust fans shall run continuously.

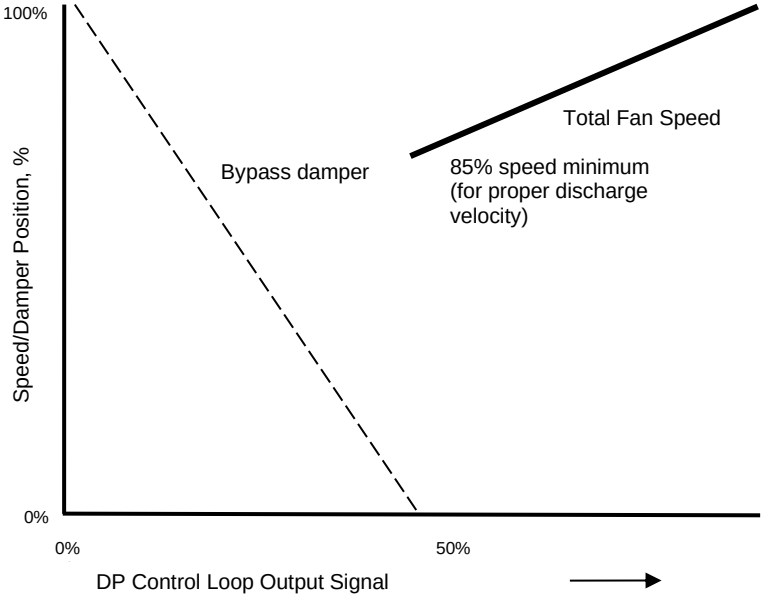
B. EF-3 shall run if either EF-1 or 2 is in alarm as indicated below until both fans are not in alarm.

C. Exhaust Plenum Pressure Control

1. Static pressure setpoint: Setpoint shall be reset using Trim & Respond logic per Guideline 36 with the following parameters:

Variable	Value
Device	Either EF
SP0	-1.0 inches
SPmax	-0.1 inches
SPmin	-2.0 inches
Td	10 minutes
T	2 minutes
I	2
R	Zone Exhaust Static Pressure Reset Requests
SPtrim	+0.05 inches
SPres	-0.06 inches
SPres-max	-0.13 inches

2. A PID loop shall maintain the main DP sensor at setpoint, the output of which shall be mapped to fan speed and bypass damper position as indicated below.



3. Fan speed to each fan shall be equal to Total Fan Speed divided by the number of exhaust fans proven on, e.g. if Total Fan Speed is 80% and both fans are proven on, each runs at 40% speed.

D. Alarms

1. Maintenance interval alarm when fan has operated for more than 2000 hours: Level 4. Reset interval counter when alarm is acknowledged.

2. Fan alarm is indicated by the status input being different from the output command for 15 seconds.
   a. Commanded on, status off: Level 2. Do not evaluate alarm until the device has been commanded on for 15 seconds.
   b. Commanded off, status on: Level 4. Do not evaluate the alarm until the device has been commanded off for 60 seconds.

3. Low static pressure (< 0.2” below setpoint) when fan control loop is active for longer than 5 minutes. Level 2.

3.15 METERING SUMMARIES

A. Provide metering summary separately for the following metering systems:

   1. Electrical power

   2. Potable water

B. For each metering system:

   1. Through a hyperlink, show a screen summarizing meter data including:
      a. Details of what is being metered
      b. Pie chart or other graphical format
      c. Summary of power on the following basis:
         1) Current
         2) Past day
         3) Past month
         4) Past year and year-to-date

3.16 MISCELLANEOUS ALARMS

A. Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output: Level 4

B. Equipment alarm (for equipment with alarm contacts such as VFDs, AC units): Level 2

C. Failure or disconnection of a sensor as indicated by signal widely out of range: Level 2.

D. Panel or LAN failure: Level 2

E. Loss of communication with any device via Gateway (e.g. VFD) for more than 30 seconds: Level 2 (alarm shall indicate which specific device is not responding).

END OF SECTION 259000