NOTICE TO ALL CONTRACTORS

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

This Addendum forms a part of the Contract Documents and modifies the original Contract Documents dated December 5, 2018, Addendum 1 dated February 12, 2019, Addendum 2 dated February 22, 2019 and Addendum 3 dated March 4, 2019. Acknowledge receipt of this Addendum in space provided on the Bid Proposal Form. Failure to acknowledge may subject Bidder to disqualification.

A. Deletions, Additions, Changes, Revisions

GENERAL

SPECIFICATIONS

1. Section 00010 Table of Contents
   Add paragraph “Division 25 – Integrated Automation, Section 25 00 00 Building Automation System”.

2. Section 00300 Bid Proposal Form
   Delete section 00300 Bid Proposal Form in its entirety and replace with attached 00300 Bid Proposal Form in its entirety.

3. Section 09 91 00 Painting
   Add paragraph, 1.2 Related Sections
     K. Section 03 93 00 FRP Strengthening Systems.
   Add paragraph, 2.6 Finishes
     B. For where 03 93 00 FRP Strengthening Systems occur on drawings, paint to be applied after installation of 09 93 00 Section 2.2 E. FRP protective coating.
4. **Section 25 00 00 Building Automation Systems.**
   Add attached spec section in its entirety.

**DRAWINGS**
All drawing modifications are indicated on the drawings with a cloud graphic and a Delta AD4.

1. **Sheet GA.A-211 Building GA – Elevations – Exterior,**
   **GA.A-212 Building GA – Elevations – Exterior**
   **G.A-212 Building G – Elevations – Exterior**
   **L.A-211 Building L – Elevations – Exterior**
   **T.A-211 Building T – Elevations – Exterior**
   Paint exposed exterior surfaces of each building, including but not limited to downspouts, fascia trims, railings, exposed ducts at mechanical yard, fence posts and framing and downspouts. A exterior painting color scheme to be provided at painting submittal review, see attached sketch AD4-A1.

2. **Sheet M-002 MECHANICAL SCHEDULES**
   Revise model numbers for CU-A1, CU-A2 and CU-A3, see attached sketch AD4-M1.

3. **Sheet M-003 MECHANICAL SCHEDULES**
   Revise MAU-L1 remarks, see attached sketch AD4-M2.

4. **Sheet M-517 MECHANICAL DETAILS AND DIAGRAMS**
   Add clarification note to detail 1 to show that valve added is a bypass valve
   Revise detail 1 note that the boilers flow switch is existing and to reinstall if outside boiler, see attached sketch AD4-M3.

5. **Sheet M-611 HVAC Controls Details**
   Delete entire sheet M-611 and replace with attached sheet M-611.

6. **Sheet M-612 HVAC Control Details**
   Delete entire sheet M-612 and replace with attached sheet M-612.

7. **Sheet M-613 HVAC Controls Details**
   Delete entire sheet M-613 and replace with attached sheet M-613.

8. **Sheet GA.E-112 BUILDING GA – POWER PLAN – LEVEL 1**
   At Unisex Restroom A209 - Add outlet box with keynote 8 on east wall above vanity for backlit mirror. Circuit outlet box to adjacent receptacle circuit.
   Add Keynote 8 to read “Provide outlet box for backlit mirror. Coordinate exact location with mirror installation requirements prior to rough-in.
9. **Sheet G.E-111 BUILDING G – POWER PLAN – LEVEL 1**
   At Men Restroom G104 - **Add** outlet box with keynote 8 on west wall above vanities for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   At Women Restroom G105 - **Add** outlet box with keynote 8 on east wall above vanities for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   **Add** Keynote 8 to read “Provide outlet box for backlit mirror. Coordinate exact location with mirror installation requirements prior to rough-in.

10. **Sheet L.E-111 BUILDING L -POWER PLANS – LEVEL 1 & ROOF**
   **Add** convenience outlet in Laundry L112, receptacles for washing machines in Laundry L112 and disconnects for dryers in Laundry L112, see attached sketch AD4-E1.

11. **Sheet L.E-111 BUILDING L – POWER PLANS – LEVEL 1 & ROOF**
   At Women’s Faculty Restroom L113 - **Add** outlet box with keynote 12 on west wall above vanity for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   At Men’s Faculty Restroom L114 - **Add** outlet box with keynote 12 on west wall above vanity for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   **Add** Keynote 8 to read “Provide outlet box for backlit mirror. Coordinate exact location with mirror installation requirements prior to rough-in.

12. **Sheet L.E-701 BUILDING L PANEL SCHEDULES**
   **Revise** panel ‘L-M’, see attached sketch AD4-E2.

13. **Sheet T.E-112 BUILDING T – POWER PLANS – LEVEL 1 & ROOF**
   At Unisex Restroom T106 - **Add** outlet box with keynote 8 on west wall above vanity for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   At Unisex Restroom T107 - **Add** outlet box with keynote 8 on west wall above vanity for backlit mirror. Circuit outlet box to adjacent receptacle circuit.

   At Team Restroom T114 - **Add** (3) outlet boxes, one above each vanity, with keynote 8 on east wall for backlit mirrors. Circuit outlet boxes to adjacent receptacle circuit.

   **Add** keynote 12 to read “Provide outlet box for backlit mirror. Coordinate exact location with mirror installation requirements prior to rough-in.
B. ANSWERS TO BIDDERS QUESTIONS

Q1: Section 03 93 00 Fiber-Reinforced Polymer (FRP) Strengthening System, paragraph 1.4.9 of the specification requires testing as per ASTM E84 but it is not clear what interior finish is required for the applied systems. Should all interior applications include a finish to achieve a class 1/A flame and smoke finish per ASTM E84?

A1: Refer to paragraph 2.2 Composite Strengthening Systems Material
E. Protective coating to be applied onto FRP to meet class A flame and smoke requirements per 03 93 00 section 1.4.9 and 2.2.E.

If you have any questions regarding this Addendum, please contact:
Ben Cayabyab, Contracts Manager
Contra Costa Community College District
500 Court St., Martinez, CA 94553
Email: bcayabyab@4cd.edu

All other terms and conditions of BID are to remain the same.

Lionakis
Architect of Record
1919 19th Street
Sacramento, CA 95811

END OF ADDENDUM #4
SECTION 00300
BID PROPOSAL FORM

PROJECT NUMBER / NAME: C-608 PE & Kinesiology Complex Renovation

CAMPUS / LOCATION: Contra Costa College, 2600 Mission Bell Drive, San Pablo, CA. 95806

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. Only bids by prime contractors that have been pre-qualified for this specific project will be accepted by the District.

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

   F. The District shall award the contract to the lowest responsive and responsible Bidder. The lowest bidder shall be determined by the sum total of Base Bid plus Alternates 1 through 9.

   G. The District reserves the right to award the Additive/Deductive Alternates, if any, through change orders as budget allows within 30 calendar days after the Award of Contract.

2. CONTRACT SUM
<table>
<thead>
<tr>
<th>BASE BID</th>
<th>ADDITIVE</th>
<th>ALTERNATE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trellis at Building GA – Gym Annex as shown on sheet AS103 Site Plan – Trellis. Base bid is no Trellis at Building GA.</td>
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</table>

<table>
<thead>
<tr>
<th>ADDITIVE</th>
<th>ALTERNATE 3</th>
<th>Wood Flooring at Dance Studio A104 at Building GA – Gym Annex, as shown on sheets GA.A-111 and GA.AF111. Base bid is existing wood floor at Dance Studio to remain.</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>ADDITIVE</th>
<th>ALTERNATE 4</th>
<th>Fabric Netting at existing chain link fence with existing vinyl slats at Pool Deck as shown on sheet AS101. Base bid is no new fabric netting at existing chainlink fence at Pool Deck.</th>
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<tbody>
<tr>
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<tr>
<td></td>
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<td>Alternate 4 (numeric)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ADDITIVE</th>
<th>ALTERNATE 5</th>
<th>Vertical Folding Partition at Building L at door nos. L108B, L116C and L120C as shown on sheets L.A-111, L.A-121 and A-621. Base bid is no vertical folding partition at Building L.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>$_______________</td>
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<tr>
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<td></td>
<td>Alternate 5 (numeric)</td>
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</tbody>
</table>
ADDITIVE ALTERNATE 6
Outdoor Fitness Area at Building GA – Gym Annex as shown on sheet AS102. Base bid is no Outdoor Fitness Area at Building GA.

Alternate 6 (written) $_____________
Alternate 6 (numeric)

ADDITIVE ALTERNATE 7
Cast In Place Exterior Benches / Seat wall as shown on sheets L-M11 and L-M51. Base bid is concrete walkway where exterior benches/seat walls are shown.

Alternate 7 (written) $_____________
Alternate 7 (numeric)

ADDITIVE ALTERNATE 8
New Windows and Openings in concrete walls at Fitness Center A113 at Building GA – Gym Annex as shown on sheets GA.AD111 and GA.A-111. Base bid is no windows and openings at Fitness Center at Building GA.

Alternate 8 (written) $_____________
Alternate 8 (numeric)

ADDITIVE ALTERNATE 9
3” concrete infill and finish flooring at Varsity Room A110 and Fitness Center A113 in Building GA – Gym Annex. Base bid is existing wood floor to remain and refinished.

Alternate 9 (written) $_____________
Alternate 9 (numeric)

TOTAL PROJECT BID
Base Bid plus Alternates 1 through 9

Total Project Bid (written) $_____________
Total Project Bid (numeric)

In the event of a discrepancy between the Total Project Bid and the Sum of Base Bid plus Alternates 1-9, the Total Project Bid will be determined by sum of the amounts listed for each line item.
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.

3. 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 ___________________

   Addendum No.: ________ dated ___________________

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

4. 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.
5. 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 the 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.

6. 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: ________________________________

7. 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.

8. 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
SECTION 250000
BUILDING AUTOMATION SYSTEMS

PART 1 GENERAL

1.1 Summary

A. Furnish and install a digital Building Automation System (BAS) as specified herein.

1.2 Coordination with other Trades

A. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. This section is provided to assist Contractor in coordination of work scope but shall not be construed to limit Contractor’s scope of work encompassed by the contract documents.

B. The following table is intended to assist the Contractors in coordinating the scope of work between Division 25 Building Automation System (indicated as 25), and other Divisions as indicated. However, the General Contractor is ultimately responsible for coordination among his subcontractors regardless of what is listed in this Section.

<table>
<thead>
<tr>
<th>INTERFACE / RESPONSIBILITY MATRIX</th>
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<tbody>
<tr>
<td>System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A. FIRE &amp; LIFE SAFETY SYSTEMS</td>
</tr>
<tr>
<td>1. Fire alarm controls</td>
</tr>
<tr>
<td>2. Duct mounted &amp; in-duct mounted smoke detectors</td>
</tr>
<tr>
<td>3. Other smoke detectors</td>
</tr>
<tr>
<td>4. Smoke control interlocks to HVAC fans</td>
</tr>
<tr>
<td>5. Smoke dampers with electric actuators</td>
</tr>
<tr>
<td>6. Smoke damper end switches</td>
</tr>
<tr>
<td>B. MECHANICAL EQUIPMENT</td>
</tr>
<tr>
<td>1. Unitary mechanical equipment</td>
</tr>
<tr>
<td>2. Variable speed drives, field mounted</td>
</tr>
<tr>
<td>3. Motors, 3 phase</td>
</tr>
<tr>
<td>4. Motor starters, 3 phase</td>
</tr>
<tr>
<td>5. Motors, 1 phase</td>
</tr>
<tr>
<td>6. Other powered equipment</td>
</tr>
<tr>
<td>7. Disconnects/circuit breakers</td>
</tr>
</tbody>
</table>
### INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
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<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
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</tbody>
</table>

#### C. BUILDING AUTOMATION SYSTEM (BAS)

1. Central control workstations & servers - - - - Existing
2. Control system network backbone 25 25 25 25 11
3. Line voltage control devices to 120V motors 25 26 26 26 6
4. Control panels 25 25 26/2 5 25 12
5. Control devices 25 25 25 25

#### D. ELECTRICAL SYSTEMS

1. Power monitoring sensors and gateway 26 26 26 26/25 14

#### E. PLUMBING SYSTEMS

1. Gas and water flow meters 25 22 25 25
2. Recirculation pumps 22 22 26 25

#### F. HVAC HYDRONIC SYSTEMS

1. Pipe gauges, thermometers, test plugs 23 23 - - -
2. Sensor wells, meters and other pipe-mounted control devices 25 23 25 25

#### G. HVAC SHEET METAL

1. Duct mounted sensors 25 23 25 25
2. Control dampers 23 23 - - 18
3. Control damper actuators 25 25 25 25 18, 19

#### H. PACKAGED VAV AIR CONDITIONING SYSTEMS

1. AC unit including all controls 23 23 23 25
2. Gateway to BAS 23 23 23 25 20

#### I. MISCELLANEOUS

1. Ceiling and wall access doors and panels 8 8 - - -

**NUMBERED REMARKS:**

1. Wiring includes raceway, fittings, wire, boxes and related items, all voltages.
2. Wiring and controls to start and stop fans based on smoke detector status and smoke control logic specified under Division 26 Electrical.
3. Factory installed starters and variable speed drives are specified under Division 23 HVAC. Prewired control panel is specified under Division 23 HVAC; single point power connection (unless otherwise noted on drawings) specified by Division 23 HVAC.
4. Applies to motors that are not covered by note 3. Integral starter control devices such as HOA switches, 120V control transformers specified under Division 26 Electrical.
5. Single phase 120V motors with integral motor overload protection specified under Division 23 HVAC.
6. Line voltage control device such as thermostat or switch specified under Division 25 BAS; wiring and conduit between control device and motor specified under Division 26 Electrical.
### INTERFACE / RESPONSIBILITY MATRIX

<table>
<thead>
<tr>
<th>System</th>
<th>Division under which the following is specified</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Equipment</td>
<td>Installation</td>
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</tbody>
</table>

7. Factory installed and wired chilled and condenser water flow switches are specified under Division 23 HVAC; no work is required under Division 25 BAS. Bi-directional (read/write) factory installed BACnet gateway between the BAS and chiller control panel specified with chiller under Division 23 HVAC; control wiring specified under Division 25 BAS. Chiller vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across chiller points to the BAS.

8. Disconnects or circuit breakers are specified under Division 23 HVAC where specifically called for in equipment schedules or specifications to be factory installed with equipment. Otherwise all disconnects are specified under Division 26 Electrical.

9. Emergency override switches, status lights and other refrigerant machinery room controls as required by CMC are specified under Division 25 BAS.

10. TDS controller, bleed valve, injector pump, make-up water flow meter, and all other water treatment system controls are specified under Division 23 HVAC. Field wiring of all components is specified under Division 25 BAS.

11. Network wiring and routers within building is specified under Division 25 BAS. Connection to campus IT LAN shall be wired by others to main building control panel. Division 25 BAS shall coordinate with campus IT for IP address.

12. 120V power to BAS control panels is specified under Division 26 for the panels shown on Drawings. Power to all other control panels that may be required is specified under Division 25 BAS, coordinated with Division 26 contractor for available circuits. Power to all BAS control panels is specified under Division 25 BAS, coordinated with Division 26 contractor for available circuits.

13. Lighting control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across lighting control points to the BAS.

14. Power measuring sensors, installation and wiring to a single central controller with Modbus interface specified under Division 26 Electrical. Modbus gateway and network connection from gateway to BAS specified under Division 25 BAS. Power monitoring control vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping across power monitoring control points to the BAS.

15. Hoods, including all required fire protection devices and integral listed balancing dampers, are specified under Division 11 Food Service.

16. Ansul type fire protection system is specified under Division 11 Food Service including all control wiring between Ansul hood and fire suppression panel, power wiring to fire suppression panel, fire alarm system monitoring intertie, gas shut-off valve interlock, and circuit breaker shunt-trips for all equipment located under the hoods.

17. PCUs with factory pre-piped fire suppression nozzles and fusible link detector brackets for Ansul type fire protection system is specified under Division 23. Field connection, tanks, controls, fusible link detectors, and commissioning is specified under Division 11 Food Service as part of hood fire protection system.

18. Duct access doors required for access to control devices where required specified under Division 23 HVAC.
19. Actuators for motorized dampers supplied with fans or hoods where scheduled on HVAC drawings are specified under Division 23 HVAC, mounted but not wired.
20. BACnet gateway to BAS specified in the Division 23 HVAC, factory installed, with connection of gateway to BAS specified under Division 25 BAS. AC vendor to provide all necessary technical assistance to Division 25 BAS Contractor in mapping AC control points to the BAS.
22. Control transformers for terminal boxes shall be centralized in control panels specified under Division 25 BAS.
23. Factory wired control transformer, safeties and contactors with single point power wiring connection specified under Division 23 HVAC.

1.3 Integration with Existing System

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

B. Procedure

1. Provide all controls work within the building as indicated on Drawings and in this Section.

2. Develop all building level control system databases and control programming using existing standards and standard programming.

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

4. Once the building BAS has been fully commissioned and accepted by the College, merge database and programming with those existing on the Control System Servers. Confirm that the merge was successful by sample testing points and sequences, and approve final installation in writing.

5. Integrate graphic screens into the Central Plant graphics including adding appropriate hyperlinks so that the system operates as one integrated system.

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

A. 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.

B. 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.

C. By submitting a proposal, contractor guarantees that their proposal is in full compliance with these specifications except as specifically excluded in their proposal.

1.5 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)

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

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.


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

F. Underwriters Laboratories

G. National Electrical Manufacturers Association
   1. NEMA 250 – Enclosure for Electrical Equipment.

H. Institute of Electrical and Electronics Engineers (IEEE)

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

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

1.6 Definitions

A. Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAC</td>
<td>Advanced Application Controller</td>
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<tr>
<td>AH</td>
<td>Air Handler</td>
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<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
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<tr>
<td>AI</td>
<td>Analog Input</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>AO</td>
<td>Analog Output</td>
</tr>
<tr>
<td>ASC</td>
<td>Application Specific Controllers</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange</td>
</tr>
<tr>
<td>ASHRAE</td>
<td>American Society of Heating, Refrigeration and Air Conditioning Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>A-to-D</td>
<td>Analog-to-Digital</td>
</tr>
<tr>
<td>BACnet</td>
<td>Data Communications Protocol for Building Automation and Control Systems</td>
</tr>
<tr>
<td>BC</td>
<td>Building Controller</td>
</tr>
<tr>
<td>BIBB</td>
<td>BACnet Interoperability Building Blocks</td>
</tr>
<tr>
<td>BTL</td>
<td>BACnet Testing Laboratory</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
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</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Drafting</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>CHWR</td>
<td>Chilled Water Return</td>
</tr>
<tr>
<td>CHWS</td>
<td>Chilled Water Supply</td>
</tr>
<tr>
<td>COV</td>
<td>Change of Value</td>
</tr>
<tr>
<td>CSS</td>
<td>Control Systems Server</td>
</tr>
<tr>
<td>CU</td>
<td>Controller or Control Unit</td>
</tr>
<tr>
<td>CV</td>
<td>Constant Volume</td>
</tr>
<tr>
<td>CW</td>
<td>Condenser Water</td>
</tr>
<tr>
<td>CWR</td>
<td>Condenser Water Return</td>
</tr>
<tr>
<td>CWS</td>
<td>Condenser Water Supply</td>
</tr>
<tr>
<td>DBMS</td>
<td>Database Management System</td>
</tr>
<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
</tr>
<tr>
<td>DHW</td>
<td>Domestic Hot Water</td>
</tr>
<tr>
<td>DI</td>
<td>Digital Input</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>D-to-A</td>
<td>Digital-to-Analog</td>
</tr>
<tr>
<td>BAS</td>
<td>Building Automation System</td>
</tr>
<tr>
<td>EMT</td>
<td>Electrical Metallic Tubing</td>
</tr>
<tr>
<td>EP</td>
<td>Electro-Pneumatic</td>
</tr>
<tr>
<td>ETL</td>
<td>Edison Testing Laboratories</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HHD</td>
<td>Hand Held Device</td>
</tr>
<tr>
<td>HOA</td>
<td>Hand-Off-Automatic</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilating and Air-Conditioning</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper-Text Transfer Protocol</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/output</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LANID</td>
<td>LAN Interface Device</td>
</tr>
<tr>
<td>MAC</td>
<td>Medium Access Control</td>
</tr>
<tr>
<td>MHz</td>
<td>Megahertz</td>
</tr>
<tr>
<td>MS/TP</td>
<td>Master-Slave/Token-Passing</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>ODBC</td>
<td>Open Database Connectivity</td>
</tr>
<tr>
<td>OI</td>
<td>Operator Interface</td>
</tr>
<tr>
<td>OWS</td>
<td>Operator Workstation</td>
</tr>
<tr>
<td>P</td>
<td>Proportional</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PI</td>
<td>Proportional-Integral</td>
</tr>
<tr>
<td>PICS</td>
<td>Protocol Implementation Conformance Statement</td>
</tr>
<tr>
<td>PID</td>
<td>Proportional-Integral-Derivative</td>
</tr>
<tr>
<td>POT</td>
<td>Portable Operators Terminal</td>
</tr>
<tr>
<td>PTP</td>
<td>Point-to-Point</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory</td>
</tr>
</tbody>
</table>
**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

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessible</td>
<td>Locations that can be reached with no more than a ladder to assist access and 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.</td>
</tr>
<tr>
<td>BACnet Interoperability Building Blocks</td>
<td>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.</td>
</tr>
<tr>
<td>BACnet/BACnet Standard</td>
<td>BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.</td>
</tr>
<tr>
<td>Change of Value</td>
<td>An event that occurs when a digital point changes value or an analog value changes by a predefined amount.</td>
</tr>
<tr>
<td>Client</td>
<td>A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Concealed</td>
<td>Embedded in masonry or other construction, installed in furred spaces, within double partitions, above hung ceilings, in trenches, in crawl spaces, or in enclosures.</td>
</tr>
<tr>
<td>Continuous Monitoring</td>
<td>A sampling and recording of a variable based on time or change of state (such as trending an analog value, monitoring a binary change of state).</td>
</tr>
<tr>
<td>Contract Documents</td>
<td>Specifications, drawings, and other materials provided with request for bids.</td>
</tr>
<tr>
<td>Control Systems Server</td>
<td>A computer(s) that maintain(s) the systems configuration and programming database.</td>
</tr>
<tr>
<td>Controller</td>
<td>Intelligent stand-alone control device. Controller is a generic reference to BCs, AACs, and ASCs.</td>
</tr>
<tr>
<td>Direct Digital Control</td>
<td>Microprocessor-based control including Analog/Digital conversion and program logic.</td>
</tr>
<tr>
<td>Building Automation System</td>
<td>The entire integrated management and control system.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Equal</td>
<td>Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.</td>
</tr>
<tr>
<td>Exposed</td>
<td>Not installed underground or concealed.</td>
</tr>
<tr>
<td>Furnish</td>
<td>To purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Gateway</td>
<td>Bi-directional protocol translator connecting control systems that use different communication protocols.</td>
</tr>
<tr>
<td>Hand Held Device</td>
<td>Manufacturer’s microprocessor based portable device for direct connection to a field Controller.</td>
</tr>
<tr>
<td>Inaccessible</td>
<td>Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.</td>
</tr>
<tr>
<td>Indicated, shown or noted</td>
<td>As indicated, shown or noted on drawings or specifications.</td>
</tr>
<tr>
<td>Install</td>
<td>To erect, mount and connect complete with related accessories.</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>Gauges, thermometers and other devices mounted in ductwork or piping that are not a part of the BAS.</td>
</tr>
<tr>
<td>IT LAN</td>
<td>Reference to the facility’s Information Technology network, used for normal business-related e-mail and Internet communication.</td>
</tr>
<tr>
<td>LAN Interface Device</td>
<td>Device or function used to facilitate communication and sharing of data throughout the BAS.</td>
</tr>
<tr>
<td>Local Area Network</td>
<td>Computer or control system communications network limited to local building or campus.</td>
</tr>
<tr>
<td>Master-Slave/Token Passing</td>
<td>Data link protocol as defined by the BACnet standard.</td>
</tr>
<tr>
<td>Motor Controllers</td>
<td>Starters, variable speed drives, and other devices controlling the operation of motors.</td>
</tr>
<tr>
<td>Native BACnet Device</td>
<td>A device that uses BACnet for communication. A device may also provide gateway functionality and still be described as a Native BACnet device.</td>
</tr>
<tr>
<td>Native BACnet System</td>
<td>A network composed only of Native BACnet Devices without gateways.</td>
</tr>
<tr>
<td>Open Database Connectivity</td>
<td>An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Open Connectivity</td>
<td>OPC is an interoperability standard developed for industrial applications. OPC compliant systems make it possible to access or exchange data from any application, regardless of which database management system is handling the data.</td>
</tr>
<tr>
<td>Operator Interface</td>
<td>A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.</td>
</tr>
<tr>
<td>Operator Workstation</td>
<td>The user’s interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.</td>
</tr>
<tr>
<td>Owner</td>
<td>The Owner or their designated representatives.</td>
</tr>
<tr>
<td>Piping</td>
<td>Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation and related items.</td>
</tr>
<tr>
<td>Points</td>
<td>All physical I/O points, virtual points, and all application program parameters.</td>
</tr>
<tr>
<td>Point-to-Point</td>
<td>Serial communication as defined in the BACnet standard.</td>
</tr>
<tr>
<td>Portable Operators Terminal</td>
<td>Laptop PC used both for direct connection to a controller and for remote dial up connection.</td>
</tr>
<tr>
<td>Primary Controlling LAN</td>
<td>High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs.</td>
</tr>
<tr>
<td>Protocol Implementation Conformance Statement</td>
<td>A written document that identifies the particular options specified by BACnet that are implemented in a device.</td>
</tr>
<tr>
<td>Provide</td>
<td>Furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.</td>
</tr>
<tr>
<td>Reviewed, approved, or directed</td>
<td>Reviewed, approved, or directed by or to Owner’s Representative.</td>
</tr>
<tr>
<td>Router</td>
<td>A device that connects two or more networks at the network layer.</td>
</tr>
<tr>
<td>Secondary Controlling LAN</td>
<td>LAN connecting AACs and ASCs.</td>
</tr>
<tr>
<td>Server</td>
<td>A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.</td>
</tr>
<tr>
<td>Standardized Query Language</td>
<td>SQL - A standardized means for requesting information from a database.</td>
</tr>
<tr>
<td>Supervisory LAN</td>
<td>Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.</td>
</tr>
<tr>
<td>Supply</td>
<td>Purchase, procure, acquire and deliver complete with related accessories.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Wiring</td>
<td>Raceway, fittings, wire, boxes and related items.</td>
</tr>
<tr>
<td>Work</td>
<td>Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.</td>
</tr>
</tbody>
</table>

1.7 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. Sunbelt. Marc Annicchero mannicchero@sunbeltcontrols.com
   - b. Air Systems. Mike Putich Mike.Putich@airsystemsin.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 1.13B.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.

1.8 Submittals

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

B. Submit drawings and product data as hereinafter specified. Conditions in this Section take precedence over conditions in Division 1 or Section 230501 Basic Mechanical Materials and Methods.

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

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

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

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

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

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

6. Submittal Package 4 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.

7. Submittal Package 5 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation. The list of points to be trended shall be submitted for approval 14 days prior to the start of the trend collection period.

D. Submission and Resubmission Procedure

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

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

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

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

5. Owner’s Representative will return a memo or mark-up of submittal with comments and corrections noted where required.

6. Make corrections
   a. Revise initial submittal to resolve review comments and corrections.
   b. Indicate any changes that have been made other than those requested.
   c. Clearly identify resubmittal by original submittal number and revision number.

7. Resubmit revised submittals until no exceptions are taken.

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

E. Submittals Packages

1. Submittal Package 0 (Qualifications)
   a. Provide Installer and Key personnel qualifications as specified in Paragraph 1.7B.
   b. Format: Word-searchable format per Paragraph 1.9C.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) Format: Word-searchable format per Paragraph 1.9C.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 specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. SOO shall be fully consistent with the graphical programming. (An electronic version of the sequences of controls in Paragraph 3.12 will be provided to the Contractor upon request.)

4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters and limits.

5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation.

d. Graphic screens of all required graphics, provided in final colors.

e. Format

1) Points list: Word-searchable format per Paragraph 1.9C.3.

2) Programming: Native ALC Eikon.

3) Programming and operating manual: Word-searchable format per Paragraph 1.9C.3.

4) Graphics: Graphical electronic format (pdf, png, etc.).

4. Submittal Package 3 (Functional Testing)

b. Provide functional test forms as required by Paragraph 3.14B.2.

c. Format: Word-searchable format per Paragraph 1.9C.3.

5. Submittal Package 4 (Training Materials)

a. Provide training materials as required by Paragraph 3.15.

b. Format: Word-searchable format per Paragraph 1.9C.3.

6. Submittal Package 5 (Trend Logs)

a. Provide a list of points being trended along with trend interval or change-of-value per Paragraph 3.14I.2.d.

b. Provide trend logs as required by Paragraph 3.14I.

1.9 Completion Requirements

A. Procedure

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

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

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

B. Completion Documents

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per Paragraph 1.9C.

a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual.

b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.

c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.

d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.
e. A list of recommended spare parts with part numbers and suppliers.

f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.

g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.

h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

i. A listing and documentation of all custom software for the Project created using the programming language, including the set points, tuning parameters, and point and object database.

j. English language control sequences updated to reflect final programming installed in the BAS at the time of system acceptance.

k. A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface.

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

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

4. Project Record Drawings

   a. As-built versions of the submittal drawings in reproducible paper and electronic format per Paragraph 1.9C.

   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 3.14B.

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 the Owner.

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.

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

D. Permanent On-site Documentation

1. In panels, provide the following in a sufficiently permanent manner such that documentation cannot be easily removed (and lost):

   a. Point list of all points in panel.

   b. Shop drawings for devices in panel.

   1.10 BAS Design

   A. System Architecture
1. General

a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified in this Section. Include all items not specifically itemized in this Section that are necessary to implement, maintain, and operate the system in compliance with the functional intent of this Section.

b. The system shall be configured as a distributed processing network(s) capable of expansion as specified herein.

c. The existing Campus BAS consists of a control system server interconnected by a high speed Supervisory LAN to each campus building and facility. This project includes integrating building level BCs and other control devices into the campus system.

1) Within the building, the BAS shall be standalone and not rely on any 3rd party networks, such as the Campus IT LAN.

2) To communicate with the central CSS (and internet via VPN), the building Supervisory LAN shall connect via router, provided under Division 25, to the Campus IT LAN, provided by the College IT group. Locate in building MDF or other location as directed by the College IT group.

d. All control products provided for this Project shall comprise an interoperable Native BACnet System. All control products provided for this Project shall conform to ANSI/ASHRAE Standard 135.

2. BAS Network Architecture

a. Supervisory LAN: The LAN shall be an Ethernet-based, 100 or 1000 Mbps network connecting the server and OWS(s) and to certain gateways as specified herein. Provide this as a dedicated LAN for the control system; the Campus IT LAN shall not be used for this purpose. LAN shall be IEEE 802.3 Ethernet with switches and routers that support 100 Mbps minimum throughput. Power-line carrier communication are not acceptable for communications. This network shall be BACnet/IP as defined in the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.

3. Operator Interfaces and Servers. The Control Systems Server (CSS) and Operator interface devices are existing. No additional CSS, OWS, or POT shall be provided as a part of this project. See Paragraph 1.3 for temporary CSS requirements.

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

5. Gateways

a. 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 3.14I.) 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space drybulb temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Ducted Air drybulb temperature</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Mixed Air drybulb temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Outside Air drybulb temperature</td>
<td>±0.5°F</td>
</tr>
<tr>
<td>Hot Water Temperature</td>
<td>±1°F</td>
</tr>
<tr>
<td>Relative Humidity – general</td>
<td>±5% RH</td>
</tr>
<tr>
<td>Relative Humidity – outdoor air</td>
<td>±3% RH</td>
</tr>
<tr>
<td>Water and Gas Flow</td>
<td>±1% of reading</td>
</tr>
<tr>
<td>Airflow (measuring stations)</td>
<td>±5% of reading</td>
</tr>
<tr>
<td>Air Pressure (ducts)</td>
<td>±0.05 inches</td>
</tr>
<tr>
<td>Air Pressure (space)</td>
<td>±0.01 inches</td>
</tr>
<tr>
<td>Electrical power</td>
<td>1% of reading</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>±75 ppm</td>
</tr>
</tbody>
</table>

#### 1.11 Ownership of Proprietary Material

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

1. Project graphic images
2. Record drawings
3. Project database
4. Project-specific application programming code
5. All documentation

#### 1.12 Warranty

**A.** At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per Paragraph 1.9B have been fulfilled, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

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

1. BCs, AACs, and ASCs: two years
2. Valve and damper actuators: five years
3. All else: one year
C. Provide new materials, equipment, apparatus and labor to replace that determined by Owner to be defective or faulty.

D. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

E. 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 Owner 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 Owner during this period.

1.13 Warranty Maintenance

A. The Owner 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 Owner, 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 Owner, 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 Owner 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 Owner'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 Owner's site within eight hours of the Owner'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 Owner to the Contractor.

   a. Response by telephone to any request for service shall be provided within eight working hours (contractor specified 40 hr. per week normal working period) of the Owner's initial request for service.

   b. In the event that the malfunction, failure, or defect is not, at least one technician, trained in the system to be serviced, shall be dispatched to the
Owner’s site within three working days of the Owner’s initial request for such services, as specified.

3. Owner’s Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers/SMS can be used for technicians trained in system to be serviced. One of the three paged/texted technicians shall respond to every call within 15 minutes.

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 ME-series

   B. Advanced Application Specific Controller (AAC)
      1. ALC SE-series
C. Application Specific Controller (ASC)

1. ALC ZN-series

2.4 Communication Devices

A. Supervisory LAN Routers

1. ALC LGR and AAR line

B. BACnet Gateways & Routers

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

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

C. Gateway and Routers

<table>
<thead>
<tr>
<th>Equipment/System</th>
<th>Interface</th>
<th>Type</th>
<th>Specified Under Division:</th>
<th>Location</th>
<th>Connect to this Network:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Speed Drives</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each VFD</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>Boiler</td>
<td>Modbus RS-485</td>
<td>23</td>
<td>Each Boiler</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>Power Monitoring</td>
<td>Modbus RS-485</td>
<td>26</td>
<td>Building Electrical Switchboard</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>BTU meters</td>
<td>BACnet/MSTP</td>
<td>25</td>
<td>Each BTU meter</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>AC Units</td>
<td>BACnet/MSTP</td>
<td>23</td>
<td>Each AC unit</td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>AC Units</td>
<td>BACnet/IP</td>
<td>23</td>
<td>Each AC unit</td>
<td>Supervisory</td>
<td></td>
</tr>
</tbody>
</table>

2.5 BAS Interface Hardware

A. Not required (existing)

2.6 Electric Wiring and Devices

A. All electrical work shall comply with Division 26.

B. Communication Wiring

1. Provide all communication wiring between Building Controllers, Routers, Gateways, AACs, ASCs and local and remote peripherals (such as operator workstations and printers).
2. Ethernet LAN: Use Fiber or Category 5 or 6 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over 30 volts.

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

C. Analog Signal Wiring

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

2.7 Control Cabinets

A. All control cabinets shall be fully enclosed with hinged door and quarter-turn slotted latch.

B. Construction

1. Indoor: NEMA 1

2. Outdoor: NEMA 3R

C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control-interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control Shop Drawings.

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

E. Provide with

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

2. Nameplates for all devices on face.

2.8 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 2.11 Points List for device specification. Only where two or more devices are specifically listed in points list (such as “FM-1 or FM-4”) may the Contractor choose among listed products.

B. Control Valves
1. Manufacturers
   a. Belimo
   b. Siemens
   c. Invensys
   d. Delta
   e. Or equal

2. Two Position Ball Valves
   a. Valves shall be specifically designed for two-position duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
   b. Industrial quality with nickel plated forged brass body and female NPT threads.
   c. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating (1 inch and smaller) or 400 psi rating (larger than 1 inch). The stem packing shall consist of 2 lubricated O-rings designed for on-off service and requiring no maintenance.
   d. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
   e. No characterization disks
   f. Close off rating: Bubble-tight shutoff greater or equal to 125% of pump shut-off head.
   g. Ball: Chrome plated brass
   h. Stem: Chrome plated brass

3. 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

4. Minimum valve assembly pressure ratings

  a. Hot water: 125 psi at 200°F

5. Valve Selection

  a. Valve type

    1) Modulating 2-way or 3-way valves

      a) 6 inch and less: characterized ball type

  b. Valve Characteristic

    1) 2-way valves: equal percentage or modified equal percentage.

    2) 3-way valves controlling heating coils: 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

      c) 3-way valves shall be selected for near minimum pressure drop. 2-way valves shall be selected near maximum pressure drop.

      d) Flow coefficient ($C_v$) shall not be less than 1.0 (to avoid clogging) unless protected by strainer. Verify from piping schematics that a strainer is being provided.

      e) Valve size shall match as close as possible the pipe size where $C_v$ is available in that size.

    2) Two-position valves: Line size unless otherwise indicated on Drawings.
C. Control Dampers

1. See Section 23 33 13 Dampers and Section 23 73 00 Indoor Air Handling Units.

D. Actuators

1. Manufacturers
   a. Belimo
   b. No equal

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

3. Electric Actuators
   a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
   b. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications.
   c. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-bolt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
   d. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.
   e. Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
   f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.
   g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.
   h. Modulating Actuators. Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a floating actuator with an analog signal converter are not acceptable.
i. Where indicated on Drawings or Points List, actuators shall include
   1) 2 to 10 VDC position feedback signal
   2) Limit (end) position switches

j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require
   more than 10 VA for AC. Actuators operating on 120 VAC power shall not
   require more than 10 VA. Actuators operating on 230 VAC power shall not
   require more than 11 VA.

k. All modulating actuators shall have an external, built-in switch to allow the
   reversing of direction of rotation.

l. Actuators shall be provided with a conduit fitting an a minimum three-foot
   electrical cable and shall be pre-wired to eliminate the necessity of opening
   the actuator housing to make electrical connections.

m. Where fail-open or fail-closed (fail-safe) position is required by Paragraph
   2.8D.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.

<table>
<thead>
<tr>
<th>Device</th>
<th>Normal Position</th>
<th>Fail-Safe Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>Return air damper</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
<tr>
<td>Exhaust/relief air damper</td>
<td>CLOSED</td>
<td>CLOSED</td>
</tr>
<tr>
<td>AHU &amp; AC heating coil valves</td>
<td>OPEN</td>
<td>LAST</td>
</tr>
</tbody>
</table>

5. Valve Actuator Selection
a. Modulating actuators for valves shall have minimum rangeability of 50 to 1.

b. Water

1) 2-way, and two-position valves

   a) Tight closing against 125% of system pump shut-off head.

   b) Modulating duty against 90% of system pump shut-off head.

2) 3-way shall be tight closing against twice the full open differential pressure for which they are sized.

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.

E. General Field Devices

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

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

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

4. 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 1.10B.2.

F. Temperature Sensors (TS)

1. General

   a. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.

   b. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise herein).

   c. Sensors shall drift no more than 0.3°F and shall not require calibration over a five-year period.

   d. Manufacturers

      1) Mamac

      2) Kele Associates

      3) Building Automation Products Inc.

      4) Automated Logic Corp.

      5) Or equal

2. Duct temperature sensors: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise.

   a. TS-1A: Single point (use where not specifically called out to be averaging in points list). Sensor probe shall be 304 stainless steel.

   b. TS-1B: Averaging. Sensor length shall be at least 1 linear foot for each 2 square feet of face area up to 25 feet maximum. Sensor probe shall be bendable aluminum.

3. Water Temperature Sensors

   a. TS-2A: Well mounted immersion sensor, ¼" stainless steel probe, double encapsulated sensor, with enclosure suitable for location.

   b. TS-2B: Same as TS-2A except provide extra precision (XP) temperature sensors to meet accuracy specified Paragraph 1.10B.2.

   c. TS-2C. See BTU-1.
d. All piping immersion sensors shall be in one-piece machined brass or stainless steel wells that allow removal from operating system, with lagging extension equal to insulation thickness where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature and fluid velocity. The well shall penetrate the pipe by the lesser of approximately half the pipe diameter or eight inches. The use of direct immersion or strap-on type sensors is not acceptable.

4. Room Sensors

a. Thermostat tags refer to the following:

<table>
<thead>
<tr>
<th>Type:</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>Blank</td>
</tr>
<tr>
<td>Temperature only</td>
<td>TS-3A</td>
</tr>
<tr>
<td>With CO₂</td>
<td>TS-3AC</td>
</tr>
<tr>
<td>Display</td>
<td>LCD</td>
</tr>
<tr>
<td>Temperature only</td>
<td>TS-3C</td>
</tr>
<tr>
<td>With CO₂</td>
<td>TS-3CC</td>
</tr>
</tbody>
</table>

1) Display

a) Blank: Blank cover (or LCD display with display configured to be shut off and touchpad or keypad disabled)

b) LCD: LCD display of all sensors, temperature setpoint adjustment buttons, and schedule override button

2) CO₂ Sensor

a) 400 to 1250 PPM/ ±30PPM or 3% of reading, whichever is greater.

b) The sensor shall include automatic background calibration (ABC) logic to compensate for the aging of the infrared source and shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.

c) Meet Title 24 requirements including calibration interval

3) For room sensors connected to terminal box controllers (such as at VAV boxes) that require calibration: Include a USB port or some other means for connection of POT for terminal box calibration. Alternative means of terminal calibration are acceptable provided they result in no cost to Work performed under Section 230593 Testing, Adjusting, and Balancing.

b. TS-3E. “Button” temperature sensor. BAPI/LP, Titan Products TPWBS, or equal.

c. TS-3F. Radiant temperature sensor. Titan Products TPRS/BB, 4-20 mA signal.

d. See equipment schedules for thermostat type.

e. Unless otherwise indicated in points list or drawings, locate sensors as follows:
1) Lobbies, corridors, break rooms, and public spaces: TS-3A
2) Equipment rooms and other back-of-house spaces: TS-3A
3) Open offices: TS-3A
4) Private offices: TS-3C
5) Conference rooms, meeting rooms, etc.: TS-3C
6) Classrooms, labs, training rooms, multi-purpose rooms, etc.: TS-3C
7) Others not listed: Confirm with Engineer through RFI.

5. TS-4: Outdoor Air Sensors
   a. Enclose in fan-aspirated radiation shield that combines both active and passive aspiration to minimize the effects of radiation.
      1) Motor-driven fan draws air through the sensor chamber and exhausts it through the top of the shield.
      2) Triple-walled sensor chamber shielded by flow-through plates.
      3) Aspiration rate: minimum is 220 feet per minute.
   b. Sensor electronics mounted in watertight gasketed enclosure to prevent water seepage
   c. Manufacturer
      1) Davis Instruments 7747
      2) Kele A21
      3) Or equal
   d. Outdoor air sensors shall have a 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.

G. BTU Meter (BTU-1)

1. Matched RTD or solid state temperature sensors with a differential temperature accuracy of +/-0.15°F.
2. Flow meter: FM-1

3. Unit accuracy shall be +/- 1% factory calibrated, traceable to NIST with certification.

4. NEMA 1 enclosure.

5. UL listed.

6. Provide BACnet/MSTP network connection that will allow all point data to be transmitted to BAS network.

7. I/O.
   a. BACnet Points:
      1) Supply Temperature
      2) Return Temperature
      3) Flow
      4) Energy Rate (Btu/hr.)
   b. Hardwired Points:
      1) Flow

8. Manufacturers
   a. Onicon System 20
   b. Siemens Sitrans
   c. Or Equal

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

f. Manufacturers
   1) Setra 209
   2) Kele & Associates P51 Series
   3) Or equal

I. Differential Pressure Transmitters (DPT)
   1. DPT-1: Water, General Purpose
      a. Fast-response capacitance sensor
      b. Two-wire transmitter, 4-20 mA output with zero and span adjustments
      c. Accuracy
         1) Overall Accuracy (at constant temp) ±0.25% full scale (FS).
         2) Non-Linearity, BFSL ±0.22% FS.
         3) Hysteresis 0.10% FS.
         4) Non-Repeatability 0.05% FS.
      d. Long Term Stability 0.5% FS per year
      e. Only 316 stainless steel in contact with fluid
      f. Pressure Limits
         1) 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.
         2) 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.
      g. Include brass 5-valve assembly for single sensor devices. See Paragraph 3.11E.6.
      h. Manufacturers
         1) Setra 209 or 230
         2) Modus W30
         3) Or equal

2. 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. Manufacturers.
   1) Setra
   2) Modus
   3) Invensys
   4) Dwyer
   5) Or equal

3. DPT-4: Air, Low Differential Pressure

a. General: Loop powered, two-wire differential capacitance cell type transmitter.

b. Output: Two-wire 4-20 mA output with zero adjustment.

c. Overall Accuracy
   1) General: ±1% FS
   2) Underfloor: ±0.5% FS
   3) Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS

d. Range
   1) Fixed (non-switch selectable)
   2) Minimum Range: 0, -0.1, -0.25, -0.5, or -1.0 inches water column
3) Maximum Range: +0.1, 0.25, 0.5, or 1.0 inches water column

4) Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.

e. Housing: Polymer housing suitable for surface mounting

f. Static Sensing Element

1) Ambient sensor: Dwyer A-306 or 420, BAPI ZPS-ACC-10, or equal

2) Space sensor: Kele RPS-W, BAPI ZPS-ACC-01, Dwyer A-417 or 465, Veris AA05 or equal wall plate sensor

3) Filter or duct pressure sensor: Dwyer A-301 or equal

4) Plenum pressure sensor: Dwyer A-421 or equal

g. Manufacturers

1) Setra 267

2) Modus

3) Air Monitor

4) Paragon

5) Or equal

J. Differential Pressure Switches (DPS)

1. DPS-1: Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0ºF to 160ºF operating temperature range.

2. DPS-2: Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Automatic reset. Provide manufacturer’s recommended static pressure sensing tips and connecting tubing.

K. Current Switches (CS-1)

1. Clamp-on or solid-core

2. Range: as required by application

3. Trip Point: Automatic or adjustable

   a. Exception: Fixed setpoint (Veris H-300 or equal) may be used on direct drive constant speed fans that do not have backdraft or motorized shutoff dampers.

4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage
5. Lower Frequency Limit: 6 Hz

6. Trip Indication: LED

7. Approvals: UL, CSA

8. May be combined with relay for start/stop

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

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

L. Current Transformers (CT)

   a. Range: 1-10 amps minimum, 20-200 amps maximum
   b. Trip Point: Adjustable
   c. Output: 0-5 Vdc or 0-10 Vdc,
   d. Accuracy: ±0.2% from 20 to 100 Hz.
   e. Manufacturers: Kele SC100, Veris 722, or equal

M. Flow Meter (FM)

1. FM-1: Magnetic Inline Flow Tube Flow Meters
   a. General Requirements
      1) Sensor shall be a magnetic flow meter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
      2) Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
      3) Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide
maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.

4) Flow Tube
   a) ANSI class 150 psig steel
   b) ANSI flanges
   c) Lined with
      1. Heating hot water: PTFE, PFA, or ETFE liner rated for 210°F minimum fluid temperature

5) Electrode and grounding material
   a) 316L Stainless steel or Hastelloy C
   b) Electrodes shall be fused to ceramic liner and not require O-rings.

6) Electrical Enclosure: NEMA 4

7) Approvals
   a) UL or CSA
   b) NSF Drinking Water approval for domestic water applications

8) Performance
   a) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and ±0.015 fps from 0.04 fps to 3 fps.
   b) Stability: 0.1% of rate over six months.
   c) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
   d) Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.

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

   a. Positive displacement, rotary type gas meter designed for volumetric measurement of widely varying flow rates of low pressure natural gas

   b. Permanent, non-adjustable calibration, not affected by low or varying line pressure and independent of the gas specific gravity, temperature, and pressure

   c. Manufactured in accordance with ANSI B109.3 for Rotary Type Gas Displacement Meters

   d. Operating temperature range: -40°F to +140°F

   e. Temperature compensating with a corrected reading for temperatures ranging from -20°F to +120°F

   f. Low frequency pulse output

   g. Rangeability at ±1% accuracy: Minimum 40 to 1

   h. Glass enclosed 8 digit totalizer, re-zeroed with on-board device

   i. Manufacturer

      1) Dresser Roots B3

      2) Or equal

3. AFMS-3

   a. Differential pressure type with uniframe DP sensor

      1) Provide quantity of DP sensors per manufacturer’s recommendations

   b. Extended flow (2 transducers, 0.05” and 0.25” range)

   c. Station mounted with expanded metal screen

   d. Analog outputs for airflow and temperature

   e. Manufacturers

      1) Air Monitor OAM-II-2111-MMAB

      2) No equal

N. Electric Control Components

1. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley, or equal.
2. Line-Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT contacts rated for 120V and current as required for application, temperature setpoint range of 50 to 95°F, and an adjustable 2-10°F setpoint differential.

3. 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.


5. 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.

2.9 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).

2.10 Software

A. General

1. System software shall be the latest version of ALC WebCTRL.

B. Licensing

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

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

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

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

C. Graphical User Interface Software

1. Graphics

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

   b. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.
c. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.

d. Links

1) Graphics shall include hyperlinks which when selected (clicked on with mouse button) launch applications, initiate other graphics, etc.

2) Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic. 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 1.9B.

2. O&M and submittal information for the devices on the graphic. See Paragraph 1.9B. This includes links to electronic O&M and submittal information for mechanical equipment supplied under Section 230501 Basic Mechanical Materials and Methods.

b) The display shall identify the target of the link by file name/address.

c) Information shall be displayed in electronic format that is text searchable.

d) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software.

e. Point Override Feature

1) Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.

2) When the point is selected to be commanded

a) Dialog box opens to allow user to override the point (Operator Mode) or release the point (Automatic Mode). Operator Mode will override automatic control of the point from normal control programs.

b) Dialog box shall have buttons (for digital points) or a text box or slide bar (for analog points) to allow user to set the point’s value when in operator mode. These are grayed out when in automatic mode.

c) When dialog box is closed, mode and value are sent to controller.

d) Graphic is updated upon next upload scan of the actual point value.
3) A list of points that are currently in an operator mode shall be available through menu selection.

f. Point override status (if a digital point is overridden by the supervised manual override per Paragraph 2.3A or if a point is in operator mode per Paragraph 2.10C.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 Owner’s intranet or internet (with appropriate security clearance) without having to disable BAS access to the database.

3) The database shall not be inherently limited in size, e.g. due to software limitations or lack of a correct license. Database size shall be limited only by the size of the provided storage media (hard drive size).

4. Security Access

a. Standard ALC WebCTRL security package

5. Report Software

a. ALC WebCTRL Enterprise Integration advanced reporting package.

b. Standard reports. Prepare the following standard reports, accessible automatically without requiring definition by user.

1) Tenant or department after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report
showing the daily total time in hours that each tenant has requested after-hours HVAC services.


3) Alarm events and status.

4) Points in Hand (Operator Override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.

D. Control Programming Software


E. Miscellaneous Software

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

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

2.11 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 2.8 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 3.14E.5.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

1. Variable speed drives

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Fault reset</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>On/off status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fault (Critical Alarm)</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Minor Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fault Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Alarm Text</td>
<td>DI</td>
<td>Through network (convert code to plain English text)</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Keypad in hand/auto</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Minimum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Maximum frequency setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Acceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Deceleration rate</td>
<td>AO</td>
<td>Through network</td>
<td>±5%</td>
<td>±5%</td>
</tr>
<tr>
<td>Actual frequency</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>AC output voltage</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Current</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>60 min</td>
</tr>
</tbody>
</table>
### Description | Type | Device | Trend Logging | Calibration
---|---|---|---|---
VFD temperature | AI | Through network | 60 min | F
Power, kW | AI | Through network | 1 min | F
Energy, MWh | AI | Through network | 15 min | –

#### 2. Boilers: Not all points available with all manufacturers (B-1)

### Description | Type | Device | Trend Logging | Calibration
---|---|---|---|---
Status/fault code 1-47 | AI | Through network | ±1 | –
Unit Status code 0-5 | AI | Through network | ±1 | –
HW supply temperature | AI | Through network | 1 min. | F
HW return temperature | AI | Through network | 10 min. | F
Exhaust temperature | AI | Through network | 10 min. | F
FFWD temperature | AI | Through network | 10 min. | F
Firing rate % | AI | Through network | 1 min. | F
O2 level | AI | Through network | 10 min. | F
CO level | AI | Through network | 10 min. | F
Flame strength % | AI | Through network | 10 min. | F
Active HWST setpoint | AI | Through network | 1 min. | F
HWST Setpoint command | AO | Through network | ±1°F | –

#### 3. Packaged IDEC units (IDEC-G1 IDEC-G2):

### Description | Type | Device | Trend Logging | Calibration
---|---|---|---|---
Unit on/off | DO | Through network | COV | –
Cooling enable | DO | Through network | COV | –
Supply air temperature setpoint | AO | Through network | ±0.5°F | –
Supply static pressure setpoint | AO | Through network | ±0.1” | –
Outdoor airflow cfm | AO | Through network | 5 min | –
Minimum OA damper position setpoint | AO | Through network | 5 min | –
Building static pressure setpoint | AO | Through network | 15 min | –
General trouble alarm | DI | Through network | COV | –
Supply fan status | DI | Through network | COV | –
<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Relief fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Communications alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Smoke Detector Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Return air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Outdoor air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply duct static pressure</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter pressure drop</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Building static pressure</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply fan speed</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Indirect evap fan speed</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Direct evap pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Indirect evap pump status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Indirect evap fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
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4. Packaged Units (AC-G1, AC-G2, AC-L1 & AC-T1 TO AC-T5):

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
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</tr>
<tr>
<td>Unit on/off</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Cooling stages enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Economizer Enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Outdoor airflow cfm</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Minimum OA damper position setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>General trouble alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Smoke Detector Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Exhaust fan status (Except AC-T3 &amp; AC-T5)</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Communications alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Outdoor air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter pressure status drop</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply fan speed</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
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</table>
5. Electrical System Monitoring. See Division 26 Drawings for quantity of meters and location of network connection.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Real kW</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Volts (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Power factor</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Amps (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
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</table>

6. Packaged Units (AC-A1 Through AC-A5):

<table>
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<th>Device</th>
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<tbody>
<tr>
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<td></td>
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<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Unit on/off</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Cooling stages</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Economizer Enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Outdoor airflow cfm</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Heating Enable</td>
<td>DO</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Minimum OA damper position setpoint</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>General trouble alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Exhaust fan status</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Communications alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Smoke Detector Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Outdoor air temperature</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Filter pressure status deep</td>
<td>AI</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Hot Water Control valve</td>
<td>AO</td>
<td>Through network</td>
<td>5 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

7. Electrical System Monitoring. See Division 26 Drawings for quantity of meters and location of network connection.

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Real kW</td>
<td>AI</td>
<td>Through network</td>
<td>15 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Volts (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Power factor</td>
<td>AI</td>
<td>Through network</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>Amps (each phase)</td>
<td>AI</td>
<td>Through network</td>
<td>–</td>
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</table>

8. BTU Meter (BTU-1)
<table>
<thead>
<tr>
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<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Return Temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Supply Temperature</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Flow</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Btu/h</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
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</table>

9. Natural Gas Flow Meter

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Flow</td>
<td>AI</td>
<td>Through network</td>
<td>1 min</td>
<td>15 min</td>
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</tbody>
</table>

D. Hardwired Points

1. Packaged IDEC units (IDEC-L1 & IDEC-L2):

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Commissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>Unit on/off</td>
<td>DO</td>
<td>Connect to VFD run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Cooling enable 1st stage</td>
<td>DO</td>
<td>Reset supply air temperature</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>stage indirect evaporative cooling</td>
<td></td>
<td>based on space zone demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling enable 2nd stage</td>
<td>DO</td>
<td>Reset supply air temperature</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>stage direct evaporative cooling</td>
<td></td>
<td>based on space zone demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply air temperature</td>
<td>AO</td>
<td>TS-1B</td>
<td>±0.5°F</td>
<td>±1°F</td>
</tr>
<tr>
<td>setpoint</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter pressure drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td>-</td>
<td>60 min</td>
</tr>
<tr>
<td>Outside Air Damper Position</td>
<td>AO</td>
<td>2-Position Damper Actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Scavenger Outside Air</td>
<td>AO</td>
<td>2-Position Damper Actuator</td>
<td>1 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Damper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct evap pump status</td>
<td>DI</td>
<td>CS-1</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Indirect evap pump status</td>
<td>DI</td>
<td>CS-1</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Direct evap pump on/off</td>
<td>DO</td>
<td>Start based on direct evap</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>on/off</td>
<td></td>
<td>enable or stop based on evap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indirect evap pump on/off</td>
<td>DO</td>
<td>Start based on indirect evap</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>on/off</td>
<td></td>
<td>enable or stop based on evap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot water control valve</td>
<td>AO</td>
<td>Modulating 2-way valve</td>
<td>1 min</td>
<td>15 min</td>
</tr>
</tbody>
</table>

2. Air Handler (AH-A1, AH-A2 & AH-A3)
<table>
<thead>
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<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Type</td>
<td>Device</td>
<td>Trend Logging</td>
<td>Calibration</td>
</tr>
<tr>
<td>Supply Fan Start/Stop</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>COV</td>
<td></td>
</tr>
<tr>
<td>Cool. enable stage 1</td>
<td>DO</td>
<td>Reset supply air temperature based on space zone demand</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Cool. enable stage 2</td>
<td>DO</td>
<td>Reset supply air temperature based on space zone demand</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Outdoor Air Damper</td>
<td>AO</td>
<td>Modulating actuator linked to outdoor air parallel blade dampers</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Return Air Damper</td>
<td>AO</td>
<td>Modulating actuator linked to return air parallel blade dampers</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Supply air temperature setpoint</td>
<td>AO</td>
<td>TS-1B</td>
<td>±0.5°F ±1°F</td>
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</tr>
<tr>
<td>Outdoor airflow cfm</td>
<td>AO</td>
<td>AFMS-3 cfm output</td>
<td>5 min 15 min</td>
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</tr>
<tr>
<td>Hot Water Control Valve</td>
<td>AO</td>
<td>Modulating 3-way valve</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Supply Fan Speed</td>
<td>AO</td>
<td>Connect to VFD Speed, all VFDs</td>
<td>1 min 15 min</td>
<td></td>
</tr>
<tr>
<td>Mixed Air Temperature</td>
<td>AI</td>
<td>TS-1B</td>
<td>1 min 15 min</td>
<td>F</td>
</tr>
<tr>
<td>Outdoor air temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min 15 min</td>
<td>F</td>
</tr>
<tr>
<td>Filter Pressure Drop</td>
<td>AI</td>
<td>DPT-3A, 0 to 1 inch</td>
<td>– 60 min</td>
<td></td>
</tr>
<tr>
<td>Supply Air Temperature</td>
<td>AI</td>
<td>TS-1A</td>
<td>1 min 15 min</td>
<td>HH</td>
</tr>
<tr>
<td>Heating hot water</td>
<td>AI</td>
<td>TS-2A</td>
<td>1 min ±2°F</td>
<td>HH</td>
</tr>
<tr>
<td>Return air temperature</td>
<td>AI</td>
<td>TS-1B</td>
<td>1 min 15 min</td>
<td>F</td>
</tr>
<tr>
<td>Filter Diff Pressure</td>
<td>AI</td>
<td>DPT-3A 0 to 1 inch</td>
<td>– 60 min</td>
<td>P</td>
</tr>
<tr>
<td>Building Pressure</td>
<td>AI</td>
<td>DPT-4</td>
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3. Fan-Coil

<table>
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<tbody>
<tr>
<td>High Temp Alarm</td>
<td>DI</td>
<td>TS (see Paragraph 3.11D.)</td>
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<td>COV</td>
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4. Exhaust Fan

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<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Start/Stop</td>
<td>DO</td>
<td>Dry contact to 120V starter control circuit</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Fan Status</td>
<td>DI</td>
<td>CS-1</td>
<td>COV</td>
<td>COV</td>
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</table>
5. Hot Water Plant

<table>
<thead>
<tr>
<th>Description</th>
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<th>Device</th>
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<th>Calibration</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<td>Comissioning</td>
<td>Continuous</td>
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<tr>
<td>Boiler B-1 enable</td>
<td>DO</td>
<td>Connect to boiler enable contact</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start HWP-1</td>
<td>DO</td>
<td>Connect to VFD Run</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>HWP speed</td>
<td>AO</td>
<td>Connect to VFD Speed on HWP-1, 2</td>
<td>1 min</td>
<td>5 min</td>
</tr>
<tr>
<td>HWS temperature</td>
<td>AI</td>
<td>TS-2A</td>
<td>1 min</td>
<td>±2°F</td>
</tr>
<tr>
<td>HWR temperature</td>
<td>AI</td>
<td>TS-2A</td>
<td>1 min</td>
<td>±2°F</td>
</tr>
<tr>
<td>HW flow</td>
<td>AI</td>
<td>FM-1</td>
<td>1 min</td>
<td>10 min</td>
</tr>
<tr>
<td>HHW Min Flow Bypass</td>
<td>AO</td>
<td>FM-3 – locate in common gas line serving both boilers</td>
<td>1 min</td>
<td>10 min</td>
</tr>
<tr>
<td>HW differential pressure</td>
<td>AI</td>
<td>DPT-1, 0 to 20 psi, located at end of piping system</td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>HW system gauge pressure</td>
<td>AI</td>
<td>PT-1, 0 to 60 psi (located near expansion tank)</td>
<td>15 min</td>
<td>1 hr</td>
</tr>
<tr>
<td>HW supply reset</td>
<td>AI</td>
<td>TS-2A</td>
<td>COV</td>
<td>160°F - 32°F; 140°F - 45°F; 120°F - 60°F Adjustabele</td>
</tr>
</tbody>
</table>

6. Domestic Water Heaters (gas, electric)

<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Device</th>
<th>Trend Logging</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Comissioning</td>
<td>Continuous</td>
</tr>
<tr>
<td>DHW System Recirculation Pumps</td>
<td>DO</td>
<td>Line voltage contact to pump power circuit</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Start/Stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHW System Recirculation Pump</td>
<td>DI</td>
<td>CS-1</td>
<td>COV</td>
<td>COV</td>
</tr>
<tr>
<td>Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHW Water Heater Alarm</td>
<td>DI</td>
<td>Through network</td>
<td>COV</td>
<td>COV</td>
</tr>
</tbody>
</table>

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 Owner’s Representative.

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

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

3.6 Controllers

A. General

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

2. Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. Except as listed below, all physical point data and calculated values required to accomplish the sequence of operation shall reside within the associated CU. Listed below are point data and calculated values that shall be allowed to be obtained from other CUs via LAN.

   a. Global points such as outdoor air temperature
b. Requests, such as heat/cool requests, used to request operation or for setpoint reset from zones to systems and systems to plants

c. Modes, such as system modes, used to change operating logic from plants to systems and systems to zones

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

B. Controller Application Categories

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

<table>
<thead>
<tr>
<th>Application Category</th>
<th>Examples</th>
<th>Acceptable Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ASC</td>
</tr>
<tr>
<td>0</td>
<td>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.</td>
<td>X</td>
</tr>
<tr>
<td>1</td>
<td>Miscellaneous heaters Constant speed exhaust fans and pumps</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Fan Coil Units Terminal Units (such as VAV Boxes) Unitary AC and HP units</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>“Slow” Lab Zone –Non-Hood Dominated</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Air Handling Units Central Hot Water Plant</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>“Fast” Lab Zone –Hood Dominated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air-Cooled Chilled Water Plant</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Water-Cooled Chilled Water Plant</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes:
Controller may be used only if all control functions and physical I/O associated with a given unit resides in one AAC/ASC

2. ASC Installation

a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
b. ASCs that control equipment mounted in a mechanical room may either be mounted in or on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.

c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

3. AAC and BC Installation

a. AACs/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.

b. AACs/BCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

3.7 Communication Devices

A. General

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

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

B. LANID and LAN Routers

1. Provide as required

2. Connect networks to both sides of device

3. Thoroughly test to ensure proper operation

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

C. Gateways and Routers to Equipment Controllers

1. See Paragraph 2.4C for network connection of gateways and routers.

2. Wire to networks on both sides of device.

3. Map across all monitoring and control points listed in Paragraph 2.11C.

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

5. Initiate trends of points as indication in Paragraph 2.11C.
D. External Communications

1. Provide an Ethernet second port on the CSS to which the Owner can connect their Owner IT LAN (intranet), by others. Contractor shall coordinate with the Owner’s Representative to establish an IP address and communications parameters to assure proper operation. This connection shall also provide access to Internet through Owner’s firewall to Internet Services Provider procured by Owner.

3.8 BAS Interface Hardware

A. Provide the following BAS Interface Hardware:

<table>
<thead>
<tr>
<th>Device</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control System Server</td>
<td>1</td>
</tr>
<tr>
<td>Operator Workstation</td>
<td>0</td>
</tr>
<tr>
<td>Portable Operator’s Terminal</td>
<td>0</td>
</tr>
<tr>
<td>Uninterruptible Power Supply</td>
<td>0</td>
</tr>
<tr>
<td>Color Inkjet Printer</td>
<td>0</td>
</tr>
<tr>
<td>Alarm Dot Matrix Printer</td>
<td>0</td>
</tr>
</tbody>
</table>

B. Install equipment as follows:

1. All else: Building Manager’s office on furniture provided by Owner.

C. Install all hardware and software and configure all devices in accordance with manufacturer’s instructions.

D. Provide all licenses, keys, etc. and all documentation and any information required to install, configure, operate, diagnose and maintain the system.

E. Connections

1. CSS
   a. Connect to Supervisory LAN
   b. Connect to Campus IT LAN.

2. OWS
   a. Connect to Supervisory LAN

3. Printers
   a. Alarm printer: Connect to CSS
   b. Color printer: Connect to OWS

F. Backup

1. After completion and acceptance of installation, create a backup of all OWSs and server database and configuration files for permanent record of initial installation.
on a flash drive. Make three copies, two for Owner and one for Contractor to retain for his records off-site.

2. All other backup configuration shall be by the Owner.

G. Anti-virus and firewall software and installation shall be by the Owner.

3.9 Control Power

A. Power wiring and wiring connections required for Work in this Section shall be provided under this Section unless specifically indicated on Division 26 Drawings or Specifications. See Paragraph 1.2.

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

1. See Division 26 Electrical Drawings for power locations pre-allocated for BAS system.

2. Where no power source is indicated on drawings, for bid purposes only, assume a dedicated circuit is available within an average of 20 feet of panel location. If this is not the case, request additional cost prior to submission of shop drawings or no additional costs will be reimbursed.

3. Coordinate with Division 26 during shop drawing development for final connection location.

C. 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 shall be powered by the highest level of reliability served.

D. Unless transformers are provided with equipment as specified in related Division 23 and 26 equipment Sections, Contractor shall provide transformers for all low voltage control devices including non-powered terminal units such as cooling-only VAV
boxes and VAV boxes with hot water reheat. Transformer(s) shall be located in control panels in readily accessible locations such as Electrical Rooms.

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

3.10 Control and Communication Wiring

A. Control and Signal Wiring


2. Line Voltage Wiring

   a. All line-voltage wiring shall meet NEC Class 1 requirements.

   b. All Class 1 wiring shall be installed in UL Listed approved raceway per NEC requirements and shall be installed by a licensed electrician.

   c. Class 1 wiring shall not be installed in raceway containing pneumatic tubing.

3. Low Voltage Wiring

   a. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)

   b. Class 2 wiring shall be installed in UL Listed approved raceway as follows:

   1) Where located in unconcealed or inaccessible locations, such as:

       a) Equipment rooms

       b) Exposed to weather

       c) Exposed to occupant view

       d) Inaccessible locations such as concealed shafts and above inaccessible ceilings

   2) Class 2 wiring shall not be installed in raceway containing Class 1 wiring.

   c. Class 2 wiring need not be installed in raceway as follows:

   1) Where located in concealed and easily accessible locations, such as:

       a) Inside mechanical equipment enclosures and control panels

       b) Above suspended accessible ceilings (e.g. lay-in and spline)

       c) Above suspended drywall ceilings within reach of access panels throughout

       d) In shafts within reach of access panels throughout
e) Nonrated wall cavities

2) Wiring shall be UL Listed for the intended application. For example, cables used in floor or ceiling plenums used for air transport shall be UL Listed specifically for that purpose.

3) Wiring shall be supported from or anchored to structural members neatly tied at 10 foot intervals and at least 1 foot above ceiling tiles and light fixtures. Support or anchoring from straps or rods that support ductwork or piping is also acceptable. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceilings.

4) Install wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

d. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two (for example relays and transformers).

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

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

6. Use coded conductors throughout with different colored conductors.

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

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

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

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

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

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

13. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment (for example steam pipes or flues).
14. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

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

16. Terminate all control or interlock wiring.

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

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

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

20. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise indicated herein, wire to the NO contact except the following shall be wired to the NC contact:
   a. Hot water pumps
   b. Coil recirculation pumps provided for freeze protection.

21. Hardwire Interlocks
   a. The devices referenced in this Section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.
   b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.
   c. Where multiple fans (or BAS DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.
   d. Provide for the following devices where indicated on Drawings or in Sequences of Operation:
      1) Duct smoke detector
      2) 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. For sensors specified to be calibrated using a dry well bath (see points list), install sensors with a sufficient wiring/flexible conduit lead that sensor may be removed from well or duct and placed in an ice bath or dry well for calibration. The spare wiring/flexible conduit shall be no less than 3 feet in length.

6. 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.

7. Unless otherwise noted on Drawings or Points List, temperature sensors/thermostats, humidity sensors/humidistats, CO₂ 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.

8. Unless otherwise noted on Drawings or Points List, install outdoor air temperature sensors on north wall where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

E. Differential Pressure Sensors

1. Supply Duct Static Pressure

   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.

   b. Low pressure port of the pressure sensor
1) Pipe to either
   a) Building pressure (high) signal of the building static pressure transmitter.
   b) Open to a conditioned space inside the building
   c) Open to the BAS panel in which the DPT is mounted provided the panel is inside the building envelope and not in an air plenum.

c. High-pressure port of the pressure sensor
   1) Pipe to the duct using a static pressure tip located as indicated on Drawings; if no location is indicated, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers.
   2) Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions.

2. Building Static Pressure
   a. Mount transmitter in temperature control panel near or in BAS panel to which it is wired.
   b. Low pressure port of the pressure sensor
      1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.
   c. High-pressure port of the pressure sensor
      1) Pipe to either
         a) Behind a BAS temperature sensor cover in an interior zone (provided sensor has openings to allow ambient air to freely flow through it)
         b) Wall plate sensor
      2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

3. Filter Differential Pressure
   a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow.
   b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.
4. All pressure transducers, 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.

5. 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.

6. Piping differential pressure transducers shall have one of the following:

   a. For sensors using two separate sensors, install test plugs on each connection for calibration and also used as vents.

F. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current. For fans with motorized discharge dampers, adjust so that fan indicates off if damper is closed while fan is running. For pumps, adjust so that pump indicates off if valve is closed while pump is running.

G. Airflow Measuring Stations: Install per manufacturer’s recommendations for unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

H. Fluid Flow Meters: Install per manufacturer’s recommendations for unobstructed straight length of pipe both upstream and downstream of sensor. Commission per the manufacturer’s startup and commissioning recommendations. Complete all manufacturer’s startup documentation and include this in prefunctional commissioning report.

I. Carbon Monoxide Sensors

   1. Quantity and location of sensors shall be determined by Contractor and shall meet code requirements and recommendations of the CO sensor manufacturer.

J. Actuators

   1. Type: All actuators shall be electric.

   2. Mount and link control damper actuators per manufacturer’s instructions.

   3. Dampers

      a. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5” open position, manually close the damper, and then tighten the linkage, or follow manufacturer’s instructions to achieve same effect.

      b. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

      c. Provide all mounting hardware and linkages for actuator installation.
4. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, mount the valve so that the position indicator is visible from the floor or other readily accessible location. However, do not install valves with stem below horizontal or down. The preferred location for the valve and actuator is on lowest point in the valve train assembly for ease of access and inspection. If this is on the coil supply piping, the control valve may be located there even if schematics (and standard practice) show valves located on the coil return piping. This comment applies to both 2-way valves and 3-way valves (which would become diverting valves rather than mixing valves in this location).

3.12 Software Installation

A. System Configuration

1. Thoroughly and completely configure BAS system software, supplemental software, network software etc. on OWS, POTs, and servers.

B. Point Structuring and Naming

1. The intent of this Paragraph is to require a consistent means of naming points across the BAS. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.

2. Point Summary Table

   a. The term “Point” includes all physical I/O points, virtual points, and all application program parameters.

   b. With each schematic, provide a Point Summary Table listing

      1) Building number and abbreviation

      2) System type

      3) Equipment type

      4) Point suffix

      5) Full point name (see Point Naming Convention Paragraph)

      6) Point description

      7) Ethernet backbone network number

      8) Network number

      9) Device ID

     10) Device MAC address

     11) Object ID (object type, instance number)
12) Engineering units

13) Device make and model number; include range of device if model number does not so identify.

14) Device physical location description; include floor and column line intersection to one decimal place (for example line 6.2 and line A.3).

c. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).

d. Coordinate with the Owner’s representative and compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup.

e. The Point Summary Table shall be kept current throughout the duration of the Project by the Contractor as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

3. Point Naming Convention

a. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.

b. Format:


2) Example: 001.HVAC.Heatplant.B-1.HWS.Temperature

<table>
<thead>
<tr>
<th>Building</th>
<th>Category</th>
<th>System</th>
<th>Equipment Tag</th>
<th>Component</th>
<th>Property</th>
<th>Typical units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELCT</td>
<td>Lighting</td>
<td>Lighting</td>
<td>SWITCH</td>
<td>Command</td>
<td>On/off</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plug</td>
<td>Plug</td>
<td>PHOTO</td>
<td>Status</td>
<td>On/off</td>
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</tr>
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<td>Light</td>
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<td>Coolplant</td>
<td>HWR</td>
<td>ValvePos</td>
<td>%open</td>
<td></td>
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<td></td>
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<td>Misc</td>
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<td>DamperPos</td>
<td>%open</td>
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<td>Flow</td>
<td>Cfm, gpm</td>
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</tr>
<tr>
<td>MISC</td>
<td>Weather</td>
<td>Weather</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
4. Device Addressing Convention

   a. BACnet network numbers and Device Object IDs shall be unique throughout the network.

   b. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner to ensure there are no duplicate BACnet device instance numbers.

   c. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner: VVVNN, where: VVV = 0-999 for BACnet Vendor ID, NN = 00 - 99 for building network.

   d. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner: 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 Owner or a designated representative to ensure that no duplicate Device Object IDs occur.

   f. Alternative Device ID schemes or cross-project Device ID duplication if allowed shall be approved before Project commencement by the Owner.

5. I/O Point Physical Description

   a. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:

      1) The device manufacturer and model number. Include range of device if model number does not so identify.

      2) For space sensors, include room number in which sensor is located.

C. Point Parameters

   1. Provide the following minimum programming for each analog input

      a. Name

      b. Address

      c. Scanning frequency or COV threshold

      d. Engineering units

      e. Offset calibration and scaling factor for engineering units

      f. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.

      g. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary or
secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides or failure of any network over which the point value is transferred.

2. Provide the following minimum programming for each analog output
   a. Name
   b. Address
   c. Engineering units
   d. Offset calibration and scaling factor for engineering units
   e. Output Range
   f. Default value to be used when the normal controlling value is not reporting.

3. Provide the following minimum programming for each digital input
   a. Name
   b. Address
   c. Engineering units (on/off, open/closed, freeze/normal, etc.)
   d. Debounce time delay
   e. Message and alarm reporting as specified
   f. Reporting of each change of state, and memory storage of the time of the last change of state
   g. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

4. Provide the following minimum programming for each digital output
   a. Name
   b. Address
   c. Output updating frequency
   d. Engineering units (on/off, open/closed, freeze/normal, etc.)
   e. Direct or Reverse action selection
   f. Minimum on-time
   g. Minimum off-time
h. Status association with a DI and failure alarming (as applicable)

i. Reporting of each change of state, and memory storage of the time of the last change of state.

j. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

k. Default value to be used when the normal controlling value is not reporting.

D. Site-Specific Application Programming

1. All site specific application programming shall be written in a manner that will ensure programming quality and uniformity. Contractor shall ensure:
   a. Programs are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
   b. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
   c. Programs are thoroughly debugged before they are installed in the field.

2. Massage and tune application programming for a fully functioning system. It is the Contractor’s responsibility to request clarification on sequences of operation that require such clarification.

3. All site-specific programming shall be fully documented and submitted for review and approval
   a. Prior to downloading into the panel (see Submittal Package 2, Paragraph 1.8.)
   b. At the completion of functional performance testing, and
   c. At the end of the warranty period (see Warranty Maintenance, Paragraph 1.13).

4. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the Project will be the property of the Owner and shall remain on the workstations/servers at the completion of the Project.

E. Graphic Screens

1. All site specific graphics shall be developed in a manner that will ensure graphic display quality and uniformity among the various systems.

2. Schematics of MEP systems
   a. Schematics shall be 2-D or 3-D and shall be based substantially on the schematics provided on Drawings.
b. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.

c. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.

d. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

3. Displays shall show all points relevant to the operation of the system, including setpoints.

4. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

5. Show weather conditions (local building outside air temperature and humidity) in the upper left hand corner of every graphic.

6. CAD Files: The contract document drawings will be made available to the Contractor in AutoCAD format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However the Owner does not guarantee the suitability of these drawings for the Contractor’s purpose.

7. Provide graphics for the following as a minimum

   a. 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 architectural Drawings. 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, domestic cold water flow, and natural gas demand 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 On-Peak or Partial-Peak demand time periods with three adjustable demand level limits for each and adjustable deadband.

      2) Electricity demand calculation. For each month, show actual peak kW and kWh for each time-of-day rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data.
d. Natural gas demand page. For each month, show actual peak therms/hr and therms for each rate period. Show side-by-side as month-this-year and month-last-year, and month-to-date and year-to-date data. Include adjustable conversion of gas volumetric flow rate to therms.

e. 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.

f. Each equipment floor/area plan: To scale, with links to graphics of all BAS controlled/monitored equipment.

g. Each air handler and fan-coil: Provide link to associated HW plants where applicable.

h. 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.

i. Electrical power monitoring system: Show a schematic of the electrical system based on one-line diagrams with meter current kW reading and month-to-date kWh shown in actual locations. Power flow shall change on the diagram (by changing line color or width) to show which power line is active.

j. Central plant equipment including hot water 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 boiler, chiller, tower, etc. as valve positions change.

k. 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) AC and Heat Pumps: operating mode; zone temperature; active heating setpoint; active cooling setpoint; supply air temperature; fan status; fan speed (where applicable); Cooling stages; Heating stages.

3) Electrical meters and switches: Volts, current, kW, switch positions.

l. 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.

m. For all equipment with lead/lag or lead/standby operation specified, show on graphic adjacent to equipment the current lead/lag order and manual buttons or switches to allow manual lead switching by the operator per Paragraph 3.13B.5.

n. For all controlled points used in control loops, show the setpoint adjacent to the current value of the controlled point.

o. All other BAS controlled/monitored equipment.

p. On all system graphics, include a “note” block that allows users to enter comments relevant to system operation.

q. All equipment shall be identified on the graphic screen by the unit tag as scheduled on the drawings.

F. Alarm Configuration

1. Program alarms and alarm levels per Sequence of Operations.

2. Each programmed alarm shall appear on the alarm log screen and shall be resettable or acknowledged from those screens. Equipment failure alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, fan alarm shall be shown on graphic air handling system schematic screen). For all graphic screens, display values that are in a Level 1 or 2 condition in a red color, Level 3 and higher alarm condition in a blue color, and normal (no alarm) condition in a neutral color (black or white).

3. For initial setup, Contractor shall configure alarms as follows:

<table>
<thead>
<tr>
<th>Criticality</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgement</td>
<td>Required</td>
<td>Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Acknowledgement of Return to Normal</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
<td></td>
</tr>
<tr>
<td>Print to alarm printer</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Email to building engineer(s)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
</tbody>
</table>
### POT Software

1. One of the POTs shall be configured to access BCs and AACs by directly connecting to these panels without having to connect to the CSS via the network. The purpose of this requirement is to provide access to building BAS panels in case the Supervisory LAN is down.

2. At the end of commissioning and then again at the end of the warranty period, fully synchronize the database on this POT with that on the CSS.

### Sequences of Operation

#### A. Sequences herein reference ASHRAE Guideline 36-2018, possibly followed by exceptions or additions where indicated. Guideline 36 sequences are not repeated herein for brevity and to make exceptions/revisions very clear. However, the final as-built sequences of operation (see Paragraph 1.9B.1.j and 2.10C.1.d.3)a1) shall include all installed sequences verbatim from Guideline 36.

#### B. General

1. Fully comply with ASHRAE Guideline 36-2018 Section 5.1 General.

2. Contractor shall review sequences prior to programming and suggest modifications where required to achieve the design intent. Contractor may also suggest modifications to improve performance and stability or to simplify or reorganize logic in a manner that provides equal or better performance. Proposed changes in sequences shall be included as a part of Submittal Package 2.

3. Include costs for minor program modifications if required to provide proper performance of the system.

4. Minimum speed setpoints for all VFD-driven equipment shall be determined in accordance with Paragraph 3.14E.7.

5. Equipment Staging and Rotation
   - a. Parallel devices shall be lead/lag or lead/standby rotated to maintain even wear.
   - b. Two runtime points shall be defined for each device:
     1) Lifetime Runtime: The cumulative runtime of the device since device start-up. This point shall not be readily resettable by operators.
2) Staging Runtime: An operator resettable runtime point that stores cumulative runtime since the last operator reset.

c. Lead/lag devices: Unless otherwise noted, parallel staged devices (such as CHW pumps and cooling towers) shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours as determined by Staging Runtime is made the last stage device and the one with the least number of hours is made the lead stage device.

C. Air Handling Units (AH-1, 2 & 3) System Modes:

1. Fully comply with ASHRAE Guideline 36-2018 Section 5.15 unless otherwise noted.

2. On call for heating as sensed by room temperature sensor, the DDC Controller shall modulate the hot water valve to maintain room temperature as sensed by the room temperature sensor.

3. On call for cooling, the DDC controller shall modulate the OA, RA, and EA economizer dampers to maintain room temperature. The OSA, RA, and EA dampers shall be positioned to admit minimum OSA flow as sense by the OSA flow measuring station when the OSA rises above 70 degrees (adj), or when the OSA temperature is higher than RA temperature. The OSA minimum position shall be reset by RA or zone C02 as scheduled.

4. On further call for cooling the economizer shall continue to operate as described above and stages of DX cooling shall be cycled to maintain room temperature as set.

   1) Minimum Fan Speed: Per Paragraph 3.14E.7

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Climate Zones</th>
<th>Required High Limit (Economizer Off When):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Dry Bulb</td>
<td>3</td>
<td>$T_{OA} &gt; 75^\circ F$</td>
</tr>
</tbody>
</table>

   b. Set economizer high limit in AC unit to disable economizer when outdoor air temperature is above 75°F.

5. Minimum Outdoor Air Control

   a. See zone CO₂ controls under Guideline 36 Zone controls.

   b. OA Setpoint (MinOA)

      1) The absolute minimum outdoor air rate, AbsMinOA, and the design outdoor air rate, DesMinOA, shall be the design minimum outdoor air rate as listed on drawings.

      2) The minimum outdoor air (MinOA) setpoint shall be reset based on the highest zone CO₂ PID loop signal from AbsMinOA at 50% signal to DesMinOA at 100% signal.
c. The active minimum outdoor air setpoint, MinOAsp, shall be determined by the equation below: (This is to prevent excess outdoor air from being supplied during off-hour, partial occupancy operation.)

\[
\text{MinOAsp} = \text{MinOA} \left[ \frac{A_{\text{active}}}{A_{\text{total}}} \right]^2
\]

where \( A_{\text{active}} \) is area of active Zone Groups and \( A_{\text{total}} \) is the overall floor area served by the system. The Contractor shall calculate the floor area of Zone Groups from drawings.

d. Minimum outdoor air control shall be controlled by the AC unit internal controls to maintain minimum outdoor air at setpoint. Setpoint shall be set to MinOAsp when the AC unit is in Occupied Mode and set to zero otherwise.

6. Alarms:

a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.

b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.

1) Commanded on, status off: Level 2.

2) Commanded off, status on: Level 4.

c. Filter pressure drop exceeds alarm limit: Level 4. The alarm limit shall vary with fan airflow rate as follows:

\[
DP_x = DP_{100}(x)^{1.4}
\]

where \( DP_{100} \) is the high limit pressure drop at design cfm (determine limit from filter manufacturer) and \( DP_x \) is the high limit at airflow rate \( x \) expressed as a fraction of design airflow rate. For instance, the setpoint at 50% of design fan airflow rate would be \((.5)^{1.4}\) or 38% of the design high limit pressure drop.

d. High supply air temperature (more than 5°F above setpoint for longer than 10 minutes.) Level 3.

e. Low supply air temperature (more than 10°F below setpoint) off heating coils when coil control loop is active for longer than 15 minutes and boiler plant is proven on: Level 3.

f. Cooling compressors operate when the outdoor air is below 55°F. Level 4.

g. Low static pressure (more than 0.25 inches below setpoint) when fan control loop is active for longer than 5 minutes: Level 3.

h. Outdoor airflow less than setpoint by 10% for 10 minutes when loop is active: Level 3.

7. Plant Requests
a. If there is a hot water coil, Hot Water Reset Requests

1) If the discharge air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests,

2) Else if the discharge air temperature is 8°C (15°F) less than setpoint for 5 minutes, send 2 Requests,

3) Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,

4) Else if the HW valve position is less than 95%, send 0 Requests

b. If there is a hot water coil and a 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:

1) If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%

2) Else if the HW valve position is less than 95%, send 0 Requests.

D. Packaged AC unit with BACnet

1. Each of the air conditioning units operates independently through its factory installed controller.

2. All setpoints are programmed into the heat pump system except for scheduling which shall be through the DDC system.

3. Alarms

   a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 5. Reset interval counter when alarm is acknowledged.

b. Unit alarm: Level 2 to 4 based on severity.

E. Packaged AC unit with DDC

1. See Paragraph Error! Reference source not found. for setpoints, loops, control modes, alarms, etc.

2. Supply fan control.

   a. For occupied spaces (e.g. office, retail): The unit fan shall run when the system is in any mode other than Unoccupied Mode.

   b. For unoccupied spaces (e.g. server rooms): The unit fan shall run when the zone is in Heating Mode or Cooling Mode.

3. Cooling control

   a. Cooling is enabled when the zone is in Cooling Mode.
b. The zone Cooling Loop output shall be mapped to stage the compressor on at 100% and off at 0%.

4. Heating control

a. Heating is enabled (reverse reversing valve contact as applicable) when the zone is in Heating Mode.

b. The zone Heating Loop output shall be mapped to stage the compressor on at 100% and off at 0%.

5. Alarms

a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 4. Reset interval counter when alarm is acknowledged.

b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.

   1) Commanded on, status off: Level 2.

   2) Commanded off, status on: Level 4.

c. Generate a Level 3 alarm if:

   1) Heating outputs are on and supply air fan is proven on and supply air temperature is below 80°F for more than 3 minutes indicating heating system failure.

   2) 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.

F. IDEC units (IDEC-L1 & IDEC L2) Sequence of Operation

1. The control system shall energize these units during occupied periods.

2. The units outside air damper shall be proven open before the supply fan and exhaust fan are energized.

3. When heat is required, the controller shall modulate the hot water control valve to maintain occupied heating space setpoint.

4. When cooling is called for, the controller shall energize the indirect cooling section and pump to maintain occupied cooling space setpoint. Upon further call for cooling, the direct evaporative section and pump shall be energized to maintain occupied cooling space setpoint.

G. Hot Water Plant

1. Parameters

   a. Temperature Setpoints
1) HWSTmax, the highest hot water supply temperature setpoint = 160°F

2) HW-LOT, the outdoor air lockout temperature above which the boiler plant is prevented from operating = 75°F

b. Minimum Flow Setpoint

1) HW-MinFlowSP, the design minimum boiler water flowrate as recommended by the manufacturer = 25 gpm for each boiler

c. Minimum Boiler Firing Rate

1) B-FiringMin, the lowest %-firing rate of the boiler before cycling = 10% for each boiler

d. Capacity

1) Qdesign, design plant capacity = total capacity of all boilers

2) Qstage, design capacity in KBtu/h for each stage

   a) Q1 = Scheduled capacity of B-1

   b) Q2 = Sum of scheduled capacity of B-1 and B-2

3) HWFdesign, design primary loop flow = total capacity of all HW pumps

e. HW Pump DP setpoint

1) HW-DPmax = as determine under 230593 Testing, Adjusting and Balancing.

2. Plant Enable/Disable

a. The Boiler plant shall include an enabling schedule that allows operators to lock out the plant during off-hours, e.g. to allow off-hour operation of HVAC systems except the Boiler plant. The default schedule shall be 24/7 (adjustable).

b. Enable the plant in the lowest stage when the plant has been disabled for at least 15 minutes and:

   1) Number of Boiler Plant Requests > I (I = Ignores shall default to 0, adjustable), and

   2) OAT<HW-LOT, and

   3) The Boiler enable schedule is active.

c. Disable the plant when it has been enabled for at least 15 minutes and:

   1) Number of Boiler Plant Requests ≤ I for 3 minutes, or
2) OAT>HW-LOT – 1°F, or

3) The Boiler enable schedule is inactive.

d. When the plant is enabled:

1) Stage on HW pump per 3.13G.4.

2) Once the pump has proven on, enable the boiler.

e. When the plant is disabled:

1) Shut off the enabled boiler.

2) Disable the operating HW pump per 3.13G.4.

3. Hot Water Supply Temperature Reset

a. Plant hot water supply temperature setpoint shall be reset using Trim & Respond logic (see Guideline 36) with the following parameters:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
<td>Any HW Pump</td>
</tr>
<tr>
<td>SP&lt;sub&gt;0&lt;/sub&gt;</td>
<td>SP&lt;sub&gt;max&lt;/sub&gt;</td>
</tr>
<tr>
<td>SP&lt;sub&gt;min&lt;/sub&gt;</td>
<td>80°F</td>
</tr>
<tr>
<td>SP&lt;sub&gt;max&lt;/sub&gt;</td>
<td>HWST&lt;sub&gt;max&lt;/sub&gt;</td>
</tr>
<tr>
<td>T&lt;sub&gt;d&lt;/sub&gt;</td>
<td>10 minutes</td>
</tr>
<tr>
<td>T</td>
<td>5 minutes</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>Heating HWST Reset Requests</td>
</tr>
<tr>
<td>SP&lt;sub&gt;trim&lt;/sub&gt;</td>
<td>-2°F</td>
</tr>
<tr>
<td>SP&lt;sub&gt;res&lt;/sub&gt;</td>
<td>+3°F</td>
</tr>
<tr>
<td>SP&lt;sub&gt;res-max&lt;/sub&gt;</td>
<td>+7°F</td>
</tr>
</tbody>
</table>

4. Primary Hot Water Pump

a. Primary hot water pump shall be controlled on when call for heating

b. Enable hot water pump when there is a call for heating. Disable the hot water pump when the boiler is commanded off

c. When the pump is proven on, pump speed shall be controlled by a reverse acting PID loop maintaining differential pressure at HW-DP<sub>max</sub>. PID loop output shall be mapped from minimum pump speed at 0% to maximum pump speed at 100%.

5. Minimum Flow Bypass Valve

a. Boiler minimum flow setpoint shall equal the sum of the minimum hot water flowrates, HW-MinFlowSP, of the boilers commanded to run.

b. A reverse acting PID loop shall maintain minimum flow as measured by the hot water flow meter at setpoint. Reset valve position from 0% open at 0% loop output to 100% open at 100% loop output.
c. When any HW pump is proven on, the bypass valve control loop shall be enabled. The valve shall be opened otherwise. When enabled, the bypass valve minimum flow PID loop shall be biased 100% (valve 100% open).

6. Alarms

a. Maintenance interval alarm when pump has operated for more than 1500 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.

b. Maintenance interval alarm when boiler has operated for more than 2000 hours as indicated by the Staging Runtime: Level 4. Reset the Staging Runtime interval counter when alarm is acknowledged.

c. Boiler alarm: Level 2

d. Low boiler leaving hot water temperature (more than 15°F below setpoint) for more than 15 minutes when boiler has been enabled for longer than 15 minutes: Level 3

e. Pump alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.

1) Commanded on, status off: Level 2

2) Commanded off, status on: Level 4

H. Domestic Water Heating

1. Recirculation pump shall operate when any AH unit serving the area that includes the toilet rooms served by the recirc pump is in Occupied Mode.

2. Alarms

a. Generate a Level 4 maintenance alarm when pump has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.

b. Pump alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.

1) Commanded on, status off: Level 2

2) Commanded off, status on: Level 4

c. Hot water supply temperature less than 110°F when recirculation pump is proven on: Level 2.

d. DHW heater alarm: Level 2

I. Toilet Exhaust Fans

1. Exhaust fans shall operate when any of the associated system supply fans is proven on and any associated Zone Group is in the occupied mode.
2. Alarms
   a. Generate a Level 4 maintenance alarm when fan has operated for more than 3000 hours. Reset interval counter when alarm is acknowledged.
   b. Fan alarm is indicated by the status input being different from the output command after a period of 15 seconds after a change in output status.
      1) Commanded on, status off: Level 2
      2) Commanded off, status on: Level 4

J. Miscellaneous Alarms
   1. 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
   2. Equipment alarm (for equipment with alarm contacts such as VFDs, AC units): Level 2
   3. Failure or disconnection of a sensor as indicated by signal widely out of range: Level 2.
   4. Panel or LAN failure: Level 2
   5. 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).
   6. Electrical switchgear alarm (from Electrical Power System gateway): Level 2

3.14 System Commissioning
   A. Sequencing. The following list outlines the general sequence of events for submittals and commissioning:
      1. Submit Submittal Package 0 (Qualifications) and receive approval.
      2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
      3. Initiate installation of BAS hardware, devices and wiring.
      4. Develop point database and application software.
      5. Simulate sequencing and debug programming off-line to the extent practical.
      6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
      7. Complete installation of BAS hardware, devices and wiring.
      8. Install point database and application software in field panels.
9. Submit Submittal Package 3 (Functional Testing) and receive approval.

10. Perform BAS Pre-functional Tests (start up, calibration and tuning) and submit completed Pre-functional Test Forms for approval.

11. Field test application programs prior to functional testing.


13. Prepare and initiate commissioning Trend Logs.

   a. Some tests may not be possible due to weather conditions. These tests may be deferred to post-occupancy period.

15. Assist in TAB tests and determining setpoints as specified in Section 230593 Testing, Adjusting and Balancing.


17. Submit Package 4 (Training Materials) and receive approval.

18. Receive BAS Functional Test Report approval and approval to schedule Demonstration Tests.


21. Train Owner personnel on BAS operation and maintenance.

22. Substantial Completion

23. Submit Package 5 (Post-Construction Trend Logs) in format specified for review and approval.

24. Receive approval of successful Trend Log tests, or retest as required.

25. Complete all items in Completion Requirements per Paragraph 1.9.

26. Provide administration level password access to the Owner.

27. Final Acceptance


29. Prepare and initiate post-occupancy Trend Logs.
30. Update all software as specified.

31. End of Warranty Period

B. Test Documentation

1. Pre-functional Tests

a. Prepare forms to document the proper startup of the BAS components.

b. All equipment shall be included on test forms including but not limited to

1) Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.

2) Digital Outputs: Proper installation, normal position, response to command at CU

3) Digital Inputs: Proper installation, device test, response at CU

4) Analog Outputs: Proper installation of devices, verification of maximum and minimum stroke.

5) Analog Inputs: Proper installation of sensors, calibration

6) Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.

7) Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.

8) Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.


c. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

d. Submit forms for approval in Submittal Package 3.

e. Complete work, document results on forms, and submit for approval as Pre-Functional Test Report.

2. Functional Tests

a. Owner’s Representatives will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
b. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc.

c. Adapt forms from Owner’s Representative into electronic format. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.

d. Submit forms for approval in Submittal Package 3.

e. Complete work, document results on forms, and submit for approval as Functional Test Report.

C. Assist Commissioning Provider/Coordinator as specified in Section 019100 Commissioning, including attending commissioning meetings.

D. Coordinate with Work specified in Section 230800 Mechanical Commissioning and Division 26 Electrical Commissioning.

E. Pre-functional tests

1. General
   a. Inspect the installation of all devices. Review the manufacturer’s installation instructions and validate that the device is installed in accordance with them.
   b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
   c. Verify integrity/safety of all electrical connections.
   d. Verify that shielded cables are grounded only at one end.
   e. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.

2. Digital Outputs
   a. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

3. Digital Inputs
   a. Adjust setpoints, where applicable.
      1) For current switches used as status on fans, adjust current setpoint so that fan status is OFF when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
      2) For current switches used as status on pumps, adjust current setpoint so that pump status is OFF when pump is dead-headed (temporarily close discharge valve).
3) For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).

4. Analog Outputs
   a. Verify start and span are correct and control action is correct.
   b. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
   c. Check all normal positions of fail-safe actuators.
   d. For outputs to reset other manufacturer’s devices (for example, chiller setpoint) and for feedback from them, calibrate ranges to establish proper parameters.

5. Analog Input Calibration
   a. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
      1) Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
      2) Handheld: Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.9.
   b. The calibrating parameters in software (such as slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician indicating date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
   c. Inaccurate sensors must be replaced if calibration is not possible.

6. Alarms and Interlocks
   a. A log shall be kept and initialed by the technician indicating date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
   b. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   c. Coordinate with Division 26 to test fire and life safety systems alarm contacts.
   d. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   e. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
7. Variable Frequency Drive Minimum Speed

a. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing motor losses to be minimal at low speeds.

b. This work shall be done only after fan/pump system is fully installed and operational.

c. Determine minimum speed setpoint as follows:

1) Start the fan or pump.

2) Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.

3) Observe fan/pump in field to ensure it is visibly rotating.

   a) If not, gradually increase speed until it is.

4) The speed at this point shall be the minimum speed setpoint for this piece of equipment.

5) Record minimum speeds in log and store in software point as indicated in Guideline 36.

8. Tuning

a. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted)

<table>
<thead>
<tr>
<th>Controlled Variable</th>
<th>Control Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duct Pressure</td>
<td>±0.1 inches w.g.</td>
</tr>
<tr>
<td>Building and relief plenum</td>
<td>±0.01 inches w.g.</td>
</tr>
<tr>
<td>Airflow and water flow</td>
<td>±10%</td>
</tr>
<tr>
<td>Space Temperature</td>
<td>±1.5°F</td>
</tr>
<tr>
<td>Duct Temperature</td>
<td>±2°F</td>
</tr>
<tr>
<td>Water Differential Pressure</td>
<td>±1.5 psi</td>
</tr>
<tr>
<td>Others</td>
<td>±2 times reported accuracy</td>
</tr>
</tbody>
</table>
9. Interface and Control Panels
   a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
   b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
   c. Check power supplies for proper voltage ranges and loading.
   d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
   e. Check for adequate signal strength on communication networks.
   f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
   g. Ensure that buffered or volatile information is held through power outage.
   h. With all system and communications operating normally, sample and record update and annunciation times for critical alarms fed from the panel to the Operator Interface.
   i. Check for adequate grounding of all BAS panels and devices.

10. Operator Interfaces
   a. Verify that all elements on the graphics are functional and are properly bound to physical devices or virtual points, and that hot links or page jumps are functional and logical.
   b. Verify that the alarm logging, paging, emailing etc. are functional and per requirements.

F. Testing, Adjusting, and Balancing (TAB) Coordination
   1. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing. Some balancing procedures require the BAS to be operational and require Contractor time and assistance.
   2. Calibration Software
      a. Software shall be provided free of charge on at least a temporary basis to allow calibration of terminal box airflow controls and other Work specified under Section 230593 Testing, Adjusting, and Balancing.
      b. Software shall be provided for installation on POT(s) provided by Others or Contractor shall loan a POT or handheld device with software installed for the duration of Work specified under Section 230593 Testing, Adjusting, and Balancing.
c. Provide sufficient training to those performing Work specified under Section 230593 Testing, Adjusting, and Balancing to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session for this purpose.

3. Setpoint Determination

   a. Perform pre-functional tests described in Paragraph 3.14B.1 before assisting in setpoint determination.

   b. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to determine fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 230593 Testing, Adjusting and Balancing.

G. Functional Tests

1. Test schedule shall be coordinated with the Commissioning Provider, Commissioning Coordinator, and Owner’s Representative.

2. Functional tests may be witnessed by Owner’s Representative at the Owner’s option.

3. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor’s start-up technician.

4. Test documentation shall be submitted to the Owner for review and approval.

H. Demonstration Test

1. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Commissioning Provider. Tests will be designed to occur over no longer than 2 working days.

2. Schedule the demonstration with the Commissioning Provider and Owner’s Representative at least 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.

3. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

4. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Commissioning Provider will supply the test forms at the site at the start of the tests.

5. Demonstration tests may be witnessed by Owner’s Representative at the Owner’s option.
6. Contractor shall conduct tests as directed by and in the presence of the Commissioning Provider and complete test forms. Completed forms shall be submitted as the Demonstration Test Report to the Commissioning Provider after tests are complete.

7. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

I. Trend Log Tests

1. Trends shall be fully configured to record and store data to the server for the points and at the interval listed in Paragraph 2.10 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 Owner’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 2.10 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 by 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.
e. Trends shall be uploaded to the CSS in data format specified in Paragraph 2.10C.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 Owner in an electronic format agreed to by the Owner and Contractor (such as flash drive or via direct access to the CSS via the internet).

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 2.10 points list.

J. Remedial Work

1. Repair or replace defective Work, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

2. Restore or replace damaged Work due to tests as directed by Owner’s Representative in writing, at no additional cost to the Owner.

3. Restore or replace damaged Work of others, due to tests, as directed by Owner’s Representative in writing, at no additional cost to the Owner.

4. Remedial Work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Owner’s Representative, at no additional cost to the Owner.

5. Contractor shall compensate Owner’s Representatives and Commissioning Provider on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional BAS trends beyond the initial tests, at no additional cost to the Owner.

3.15 TRAINING

A. Coordinate schedule and materials with Commissioning Authority.

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. ALC Training
   a. It may be assumed that College building engineers have been previously trained on the existing ALC system.
   b. Include training on ALC system operations only for new features installed at CSS/OWS as a part of this project.

3. Jobsite Training
   a. Include 40 hours total of on-site training to assist personnel in becoming familiar with job-specific issues, systems, control sequences, etc.
   b. College shall be permitted to videotape training sessions.

4. Training may be in non-contiguous days at the request of the College.

5. During the warranty period, provide unlimited telephone support for all trained operators.

END OF SECTION 250000
## EXTERIOR FINISH SCHEDULE

<table>
<thead>
<tr>
<th>MAT #</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP-1</td>
<td>CEMENT PLASTER SYSTEM</td>
</tr>
<tr>
<td>TB-1</td>
<td>BRICK VENEER SYSTEM</td>
</tr>
<tr>
<td>TB-2</td>
<td>THIN BRICK VENEER</td>
</tr>
<tr>
<td>MP-1</td>
<td>ACM PANEL SYSTEM</td>
</tr>
<tr>
<td>MP-2</td>
<td>ACM PANEL SYSTEM</td>
</tr>
<tr>
<td>GL-1</td>
<td>INSULATED GLASS</td>
</tr>
</tbody>
</table>

**BASIS OF DESIGN**
- EXTERIOR PLASTER SYSTEM: INTEGRAL PLASTER COLOR
- BRICK VENEER SYSTEM: H.C. MUDDOX
- THIN BRICK VENEER: H.C. MUDDOX
- ACM PANEL SYSTEM: ALUCOBOND
- INSULATED GLASS: VITRO ARCHITECTURAL

**COLORS**
- DE5351 - AZTEC AURA
- DET461 - CITRUS HONEY
- DE5881 - NEWBURY PORT
- DE5812 - DREAMY BLUE
- DE5737 - AQUA BLOOM

---

## EXTERIOR PAINT FINISH SCHEDULE

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</thead>
<tbody>
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<td>EP-1</td>
<td>EXTERIOR PAINT - ACCENT COLOR</td>
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</tr>
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<td>EP-3</td>
<td>EXTERIOR PAINT - ACCENT COLOR</td>
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<tr>
<td>EP-4</td>
<td>EXTERIOR PAINT - FIELD COLOR</td>
</tr>
<tr>
<td>EP-5</td>
<td>EXTERIOR PAINT - ACCENT COLOR</td>
</tr>
</tbody>
</table>

**BASIS OF DESIGN**
- EXTERIOR PAINT: DUNN EDWARDS

**COLORS**
- DE5351 - AZTEC AURA
- DET461 - CITRUS HONEY
- DE5881 - NEWBURY PORT
- DE5812 - DREAMY BLUE
- DE5737 - AQUA BLOOM
# Air Cooled Condensing Unit for AH Units

<table>
<thead>
<tr>
<th>MARK</th>
<th>CARRIER MODEL NO.</th>
<th>NO</th>
<th>RLA EA</th>
<th>LRA EA</th>
<th>CONDENSER FAN</th>
<th>RS RL</th>
<th>ELECT. SERVICE V/Ø/HZ</th>
<th>MCA</th>
<th>MOCP</th>
<th>EER</th>
<th>UNIT SERVED</th>
<th>WEIGHT (LBS)</th>
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<tbody>
<tr>
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<td>38AUDA14</td>
<td>1</td>
<td>18.6</td>
<td>125</td>
<td>2</td>
<td>-</td>
<td>1-3/8</td>
<td>3/4</td>
<td>460/3/60</td>
<td>25.0</td>
<td>AH-A1</td>
<td>600</td>
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<tr>
<td>ACCU-A2</td>
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<td>12.2</td>
<td>190</td>
<td>2</td>
<td>-</td>
<td>1-1/2</td>
<td>5/8</td>
<td>460/3/60</td>
<td>17.0</td>
<td>AH-A2</td>
<td>400</td>
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<td>ACCU-A3</td>
<td>38AUD20</td>
<td>1</td>
<td>9.7</td>
<td>62</td>
<td>2</td>
<td>-</td>
<td>1-1/8</td>
<td>12</td>
<td>460/3/60</td>
<td>12.0</td>
<td>AH-A3</td>
<td>400</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Coordinate with electrical for power and NEMA 3R disconnect switch.
2. Provide NEMA premium efficiency motor.
3. Provide mounting platform per detail M-512.
### MAKE-UP AIR UNIT SCHEDULE

<table>
<thead>
<tr>
<th>MARK</th>
<th>GREENHECK MODEL NO.</th>
<th>CFM</th>
<th>ESP (IN. WG.)</th>
<th>RPM</th>
<th>BHP</th>
<th>HP</th>
<th>MEDIA</th>
<th>REQUIRED GPM</th>
<th>LAT °F</th>
<th>INOUT MBH</th>
<th>OUTPUT MBH</th>
<th>ELECT. SERVICE V/ph/Hz</th>
<th>MIN CIR AMPS</th>
<th>MOP</th>
<th>APPROX OPER WT. LBS</th>
<th>FILTERS QTY. &amp; SIZE</th>
<th>UNIT SIZE (L&quot;xW&quot;xH&quot;)</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
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<td>MAU/L1 IGX-115H22</td>
<td>4260</td>
<td>0.625</td>
<td>833</td>
<td>1.98</td>
<td>3</td>
<td>CELed</td>
<td>0.4</td>
<td>68</td>
<td>68</td>
<td>250</td>
<td>200</td>
<td>460/3/60</td>
<td>7.5</td>
<td>1405</td>
<td>(2) 16&quot;x20&quot;x2&quot;</td>
<td>115x44x44</td>
<td>SEE NOTES 1-16</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. DOWNBLAST.
2. FURNACE CONTROL: 8 STAGE
3. LOUVERED INTAKE & ALUMINUM MESH FILTERS.
4. OUTDOOR INTAKE AT END.
5. DOUBLE WALL CONSTRUCTION.
6. HINGED ACCESS.
7. PROVIDE WITH DIRTY FILTER MONITORING (ADJUSTABLE TO BE PASSED THROUGH BMS NETWORK)
8. HEAT INLET SENSOR.
9. FACTORY PROVIDED BMS/BACNET MS/TP COMMUNICATION CONTROL INTERFACE
10. END SWITCH.
11. FACTORY PROVIDED 12" RIGID ROOF CURB.
12. AUTO DRAIN.
13. PROVIDE WITH 2 SPEED VFD ON SUPPLY FAN FOR INTERLOCK WITH LAUNDRY OPERATION.
14. PERMATECTOR FINISH
15. AMBIENT CONDITIONS: 90°F DB/65°F WB (SUMMER), 34°F WB (WINTER)
16. PROVIDE WITH DUCT SMOKE DETECTOR.
1. Run all drains to floor sink.
2. Install MAV (manual air vent) at all high points of the heating hot water system in mechanical room.
3. Install all items requiring service or monitoring in an easily accessible location.
IF THIS SHEET IS NOT 30"x42", IT IS A REDUCED PRINT
SCALE ACCORDINGLY

- CONTROLS SHOWN ARE FACTORY PROVIDED (INSIDE DASHED LINES). SEE SPECIFICATION 25 00 00 FOR POINTS INSTALLED BY TCC FOR BMS MONITORING POINTS.

2. CONTROLS SHOWN ARE FACTORY PROVIDED (INSIDE DASHED LINES). SEE SPECIFICATION 25 00 00 FOR POINTS INSTALLED BY TCC FOR BMS MONITORING POINTS.

1. CONTROLS SHOWN ARE FIELD INSTALLED AND ARE TO BE PROVIDED BY THE TCC. SEE SPECIFICATION 25 00 00 FOR POINTS INSTALLED BY TCC FOR BMS MONITORING POINTS.

NOTES:

1. CONTROLS SHOWN ARE FIELD INSTALLED AND ARE TO BE PROVIDED BY THE TCC. SEE SPECIFICATION 25 00 00 FOR POINTS INSTALLED BY TCC FOR BMS MONITORING POINTS.

2. DPS SHALL ALARM WHEN FILTER DIFFERENTIAL PRESSURE IS 0.75" W.G. (ADJUSTABLE). PROVIDED AND INSTALLED BY TCC.

DRAIN AND FILL VALVES ARE BY THE FACTORY AND THEIR CONTROLS.

OSA DAMPER

TWO POSITION

BY FACTORY. ALL ELSE UNLESS NOTED OTHERWISE).

IN ASHRAE 62.1 2010, APPENDIX C (SETPOINT AS 1000ppm CO₂)

CO₂ CONCENTRATION EXCEEDS THE SETPOINT BY MORE THAN 10%. CO₂ SETPOINTS SHALL BE BASED ON METHODS LAID OUT IN ASHRAE 62.1 2010.

ALL DENSELY OCCUPIED SPACES.

FILTER INDIRECT H₂O PUMP H₂O PUMP NC FILL FILL NC DRAIN DRAIN

OSA

DMP FILTER INDIRECT DIV 26

DIRECT

EVAP. COOLER

H₂O PUMP

H₂O PUMP NC FILL NC FILL DIV 26 PWR/FA PWR

EVAP. COOLER

SA-T DSD

HWS SUPPLY TEMP

VFD ENABLE

AO

AI

FAN START/STOP

TEMPERATURE CONTROL VALVE, TCC

COMMUNICATION

MS/TP

BACNET

PWR/FA, BY DIV 26

72 72 °F

57 °F

69 °F

SET TO

SET TO

SET TO

72 72 °F

57 °F

69 °F

₂

SET TO

SET TO

SET TO

72 72 °F

57 °F

69 °F

₂

SET TO

SET TO

SET TO

REFERENCES

DIV. OF THE STATE ARCHITECT

PETERS

2600 MISSION BELL DRIVE

SAN PABLO, CA 95806

ENGINEERING

PETERS

2841 ALHAMBRA BLVD, STE. 100

SACRAMENTO, CA 95817

19TH STREET

SACRAMENTO, CA 95811

CONSULTANT

WWW.LIONAKIS.COM

CARBON DIOXIDE MONITORING

IDEC-G1 IDEC-G2 GAS HEAT DEC/IDEC UNIT CONTROL DIAGRAM

IDEC-L1 IDEC-L2 HW COIL DEC/IDEC UNIT CONTROL DIAGRAM

500 COURT ST, MARTINEZ, CA 94553

KINESIOLOGY RENOVATION

ADD NO. 4 03/08/19 ADDENDUM 4

E R G I N S T R U M E N T S

LIONAKIS 2015

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PROJECT NO:

SHEET

TITLE

MANAGEMENT

PHYSICAL EDUCATION & KINESIOLOGY RENOVATION

CONTRA COSTA COMMUNITY COLLEGE DISTRICT

2000 KISBERG MILL DRIVE

SACRAMENTO, CA 95826

ISSUED

SEAL

COPY: TCC

FILE NO: T-C1

M-612

HVAC CONTROLS DETAILS

01-117456

017034

03/08/2019

12/31/19

EXP.

57 °F

SET TO

57 °F

SET TO

69 °F

SET TO

69 °F

SET TO

69 °F

SET TO
MAKEUP AIR UNIT MAU-L1 CONTROL DIAGRAM

HOT WATER SYSTEM CONTROL DIAGRAM

HOT WATER BTU MONITORING DIAGRAM

DHW SYSTEM SCHEMATIC

TYPICAL FAN COIL CONTROL DIAGRAM

NATURAL GAS FLOW METER CONTROL DIAGRAM

HOT WATER SYSTEM CONTROL DIAGRAM

ELECTRICAL POWER MONITORING PANEL DIAGRAM
### Branch Panel: L-M

**Location:** MECHANICAL ROOM L122  
**Volts:** 480/277 Wye  
**A.I.C. Rating:** 35,000  
**Supply From:**  
**Mounting:** Surface  
**Enclosure:** Indoor

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<th>Trip</th>
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<th>B</th>
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**Load Classification:**  
- HVAC: 1745 VA, Demand Factor: 100.00%, Estimated Demand: 1745 VA  
- Motor: 3000 VA, Demand Factor: 125.00%, Estimated Demand: 3750 VA  
- Power: 221400 VA, Demand Factor: 100.00%, Estimated Demand: 221400 VA

**Panel Totals:**  
- Total Conn. Load: 228148 VA  
- Total Est. Demand: 228895 VA  
- Total Conn.: 273 A  
- Total Est. Demand: 273 A

**Notes:**  
- IEM PU W/ GE BREAKERS