



REQUEST FOR PROPOSAL
PROJECTS \$60,000 to \$200,000

- 1.0 NOTICE TO PROPOSERS**
- 2.0 INSTRUCTIONS TO PROPOSERS**
- 3.0 PROPOSAL**
- 4.0 BID BOND**
- 5.0 GENERAL CONDITIONS OF THE AGREEMENT**
- 6.0 PROJECT SCOPE**
- 7.0 ATTACHMENTS**

- PROJECT: West Hills Community College District
West Hills College Coalinga**
- **WEST HILLS
COLLEGE- EMCS
UPGRADES**
 - **300 Cherry Lane
Coalinga, CA 93210**

1.0 NOTICE TO PROPOSERS
Request for Proposal

DATE: **November 21, 2022**

TO: Qualified Proposers

FROM: Shaun Bailey
West Hills College Coalinga
300 Cherry Lane.
Coalinga, CA 93210

PROJECT: WEST HILLS COLLEGE- EMCS UPGRADES

PROJECT DESCRIPTION: This project will require the removal and replacement of the Building . The Contractor will include all labor, materials, and equipment to complete the work.

LICENSE REQUIRED: **C-20, C-10, and C-36**

PROPOSAL DATE/TIME: **December 16, 2022 at 2:00pm**

PROPOSAL LOCATION: Proposals can be emailed to: Purchasing@whccd.edu
or delivered to:
West Hills College Coalinga, M&O Department
300 Cherry Lane
Coalinga, CA 93210

BID SECURITY BOND: Required 10% Bid Bond if proposal is \$15,000 or over.

PERFORMANCE AND PAYMENT BOND: Required if proposal is \$25,000 or over.

PREVAILING WAGE PROJECT: **Yes**

**CONTRACT DOCUMENTS AND SPECIFICATIONS
MAY BE OBTAINED AT ADDRESS BELOW:**

CONTACT PERSON: Shaun Bailey
(559) 934-2254
E-mail: shaunbailey@whccd.edu

**MANDATORY SITE VISIT: December 6th, 2022 at 10:00am. West Hills College
Coalinga M&O Building**

2.0 INSTRUCTIONS TO PROPOSER

PART 1 - GENERAL

A. SECURING DOCUMENTS:

1. Contractors obtaining these plans and project manual for the purpose of submitting proposals for this work shall notify the District of their intentions, together with mailing address and telephone number, so they may be fully advised of any addenda to the construction documents being figured, or of any corrections, additions or omissions. Failure to so notify the District will make the contractor liable for the inclusion of all information according to the addenda in this contract, whether received or not.
2. Construction documents will not be issued to contractors who are not licensed to do business in the State of California, and the District will not consider or accept any proposal or proposals from such contractors.
3. Proposers shall have a generally recognized record for satisfactory execution of contracts of a similar size and character.

B. EXAMINATION OF PROPOSAL DOCUMENTS:

1. Each proposer shall examine the proposal documents carefully prior to date for receipt for proposals, shall make written request for interpretation and/or correction of any ambiguity, inconsistency or error therein which he may discover.
Any interpretation and/or correction will be issued as an Addendum. Only a written interpretation and/or correction by Addenda shall be binding. No proposer shall rely upon any interpretation and/or correction given by any other method.
2. By submitting a proposal, the proposer implies that he has thoroughly investigated and is satisfied as to the character quality and quantities of work to be performed and materials to be furnished, and as to all the stipulations and requirements of the Contract and construction documents.
3. The Proposer shall diligently investigate existing conditions to ascertain work required and include all necessary cutting and patching and refinishing in his proposal. He shall provide for and exercise every precaution to protect the existing facilities against dust, dirt, water, trash, interruption of personnel activities, etc., due to operations under this Contract.
4. The District will not be responsible for any omissions, errors, etc., which may result from the Contractor's procurement of incomplete documents. It shall be the Contractor's responsibility to review and ascertain all of the required work, materials, etc., to be provided by him in performing all work as required and/or called for by the Contract Documents.

C. INTERPRETATION OF DOCUMENTS:

Should a proposer find discrepancies in, and/or omissions from the drawings and specifications, and/or should he be in doubt as to their meaning, he shall at once notify the District and should it be found necessary, a written addendum or clarification will be sent to all Proposers. The District will not be responsible for oral instructions.

1. Questions during proposal period shall be submitted in writing to Shaun Bailey. Email or Fax copies will be accepted.
2. No questions will be answered 48 hours prior to proposal opening.
3. E-mail questions will be accepted within the above time limits. shaunbailey@whccd.edu

D. PROPOSALS:

Proposals to receive consideration shall be made in accordance with the following instructions:

1. Proposals shall be made upon the proposal forms, properly executed and with all items filled out; numbers shall be stated both in writing and in figures. The complete proposal form shall

- be without alterations to content, form, and scope project; and the signatures of all persons signing shall be in longhand.
2. Alternate proposals will not be considered unless called for. No oral, telegraphic or telephonic proposals or modifications will be considered.
 3. Before submitting proposals for this work, including RFP's, each proposer will be held to have examined the project premises and satisfied himself as to the existing conditions under which he will be obliged to operate, and that no changes will be made subsequently in this connection or in behalf of the Contractor for any error or negligence on his part, and he shall include in the proposal a sum to cover the cost of all items included in the contract and/or subsequent RFP's. No additional cost will be considered for price increases of any materials, labors, methods and/or procedures. The Contractor shall make allowances for any and all price changes occurring during this project from proposal through final completion and project acceptance by District.
 4. Proposals will be delivered to the District at locations and time noted on "Bid Proposal" on or before the day and hour set for the opening of proposals. Proposal forms shall be enclosed in an envelope and bear the title of work and the name of the proposer. It is the sole responsibility of the proposer to see that his proposal is received in proper time and location. Any proposal received after the scheduled closing time for receipt of proposals will be returned to the proposer. Email proposals to purchasing@whccd.edu.
 5. Each proposer shall include with Proposal a Non-Collusion Affidavit, Prevailing Wage Compliance Certificate, required bond documents, and Certification of Workmen's Compensation to be executed by proposer and submitted with proposal. Form is included in "Bid Proposal" section. Form shall be fully executed and included with Proposal.
 6. General Information:
 - a. The District reserves the right to reject any or all proposals and/or waive any irregularities or informalities in any proposals and/or in the proposals process.
 - b. The District has determined the general prevailing rate of per diem wages in the locality in which this work is to be performed for each craft or type of worker needed to execute this Contract. These rates are available on the Internet at the following address: www.dir.ca.gov/DLSR/statistics_research.html. Copies may be downloaded by the Contractor.
 - c. The schedule of per diem wages is based upon a working day of eight hours. The rate for holiday and overtime work shall be at least time and one half.
 - d. It shall be mandatory upon the Contractor to whom the Contract is awarded (Contractor), and upon any subcontractor under him, to pay not less than the specified rates to all workers employed by them in the execution of the Contract. It is Contractor's responsibility to determine any rate change which may have or will occur during the intervening period between each issuance of written rates by the Director of Industrial Relations.
 - e. If awarded, proposal will be awarded to the lowest qualified proposal.
- E. **WITHDRAWAL OF PROPOSAL:**
Proposals may be withdrawn by the Proposer prior to, but not later than, the time fixed for opening of proposals.
- F. **CORPORATION AS PROPOSER:**
In case a proposal is submitted by a corporation, it shall be signed in the name of such corporation by a dully authorized officer or agent thereof.
- G. **SALES TAXES:**
Sales taxes and any or all taxes and any other City, County, State, or Federal, except property taxes shall be included in the proposal. All proposals shall include all license fees, permit fees, and other fees to complete this project. See herein for permits, inspections, and assessments required for this project.

H. ADHERENCE:

No proposal will be considered that does not strictly adhere to all requirements of these instructions to Proposers.

I. PROPOSALS TO BE ACCEPTED BY DISTRICT:

The successful contractor shall be determined by the lowest total aggregate proposal of any or all proposals accepted by the District. The District reserves the right to select the proposals and/or aggregate of proposals it deems advantageous to the District.

J. AWARD OR REJECTION OF PROPOSALS:

The contract shall be awarded to the responsible proposer complying with these instructions. The District reserves the right to reject any and all proposals and to waive any informality or irregularity in proposals received. The award, if made, will be made within sixty (60) calendar days after the opening of the proposals.

K. EXAMINATION OF SITE:

The Proposer shall carefully examine the site of the contemplated work prior to submitting a proposal and shall have satisfied himself as to the existing conditions and the conditions under which he will be obligated to operate, and/or that will in any manner affect the work under the contract. No allowance will be made subsequently in this connection for items that could be reasonably be inferred to be required to complete project scope from a careful examination of site of the contemplated work.

L. ADDENDA AND BULLETINS:

Any addenda or bulletin items issued during the time of proposals shall be an integral part of the Contract Documents used by the Proposer for the preparation of his proposal, all items of addenda and/or bulletins shall be included in the Proposal and shall be made part of the Contract. Delivery of any Addenda or Bulletin in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, delivery by mail to the last known business address of the Contractor, or fax transmittal with telephone confirmation of complete receipt and or email will be considered to be proper service of said documents.

M. PERMITS, INSPECTIONS AND ASSESSMENTS, ETC.:

No building permits required for this project.

List of fees/assessments:

1. None.

N. FORMAL PROTEST OF PROPOSAL:

Any proposer submitting a proposal to the District or a third party may file a protest against District awarding contract on this project provided that protestor meet all of the following requirements:

1. Protest shall be submitted in writing and received on or before 72 hours after proposal opening time. Protest received after that shall not be recognized.
2. Protest of any proposals shall be filed and received by the Chief Business Officer, of the District by certified mail or by personal delivery during normal working hours, for administrative appeal.
3. Protest Submittal shall contain the following:
 - a. The written proposal protest sets forth, in detail, all grounds for the proposal protest, including without limitation all facts, supporting documentation, legal authorities and argument in support of the grounds for the proposal protest; any matters not set forth in written proposal protest shall be deemed waived. All factual contentions must be supported by competent, admissible and creditable evidence.
 - b. Name, address, phone number of person(s), company and/or organization that is making protest and name of project protest is for.

4. Any proposal protests not conforming to the foregoing shall be rejected by the Owner as invalid. Provided that a proposal protest is filed in conformity with the foregoing, the Owner's Chief Business Officer or such individual(s) as may be designated by the Chief Business Officer, in his discretion, shall review and evaluate the basis of the proposal protest, and shall provide a written decision to the proposer submitting the proposal protest concurring with or denying the proposal protest. The written decision of the Chief Business Officer shall be considered an administration appeal.
5. The protest decision by the Chief Business Officer may be appealed to the Board of Trustees as a judicial appeal. This request must be filed with the Chief Business Officer within 72 hours of receipt of the written decision of the Chief Business Officer. Said appeal shall be accompanied with reason for appeal. The judicial appeal will be calendared within 31 days or less of receipt. The final decision of the Board of Trustees is not subject to arbitration, mediation or reconsideration/appeal.

O. **STARTING WORK:**

All documents shall be submitted and approved prior to starting work. Failure to provide complete information prior to days indicated shall be considered non-responsive, bid bond will be forfeited, and Contractor shall be declared in default.

- | | | |
|----|---|---|
| 1. | All insurance certificates - | 10 days- Following award |
| 2. | Proof of Contractor's/Subcontractor's license - | 10 days -Following award |
| 3. | Start work | 45 days from notice to proceed
and/or purchase order |

PART 2 - PERFORMANCE OF WORK UNDER CONTRACT

A. **SUPERVISION:**

The General Contractor and all subcontractors engaged by general contractor will be required to designate one responsible on-site person with authority to receive directions and issue instructions for the orderly prosecution of the work.

B. **BUILDING CODE REQUIREMENTS:**

1. All work performed under this Contract shall conform to the applicable portions and editions of the following current codes:
 - a. California Building Code--CCR, T24 Parts 1-9.
 - b. Public Health Code of the California State Department of Public Health and Local Health Department.
 - c. California Occupational Safety and Health Act (CAL/OSHA).
 - d. Rules and regulations of the State and Local Fire Marshals.
 - e. Safety Orders of the Industrial Accident Commission, State of California.
 - f. National Electric Code.
 - g. Uniform Plumbing Code.
 - h. All laws governing the employment of labor, posting of minimum wage rates, and accident prevention.
 - i. Americans with Disabilities Act, Federal law.
2. Requirements of enforcing authorities may supersede requirements of the above laws and regulations, and nothing in the Contract Documents shall be construed to permit work not conforming to applicable codes.
3. All of the above laws and regulations are as much a part of this contract as if they were incorporated in their entirety herein.

C. **BID AND PAYMENT BOND:**

General Contractor shall take out and maintain Bid and Labor/Payment bonds as indicated herein. The Bond requirement will vary based on the project proposal. The following criteria will determine Bond Requirements.

1. Bid Bond/Security. Proposals shall be accompanied with a Bid security 10% of project amount for all contacts \$15,000 or more.

- a. Each bid/proposal shall be accompanied by a bid security pursuant to Public Contracts Code 20674, in cash, a certified or cashier's check, or bid bond in an amount not less than 10 percent of the total bid price payable to the Owner. The bid security shall be given as a guarantee that if awarded the contract the bidder will execute and return the Construction Agreement within 10 working days after award of the contract and will furnish on the prescribed forms a satisfactory Payment
 - b. (Labor and material) Bond and separate Performance Bond, in accordance with the Contract Documents and Civil Code Section 3248, and certificates evidencing that the required insurance is in effect in the amounts set forth in the Contract Documents. In case of refusal or failure to timely execute the Construction Agreement and furnish the required bonds and insurance certificates, the bid security shall be forfeited to the Owner. If the bidder elects to furnish a bid bond as its bid security, the bidder shall use the bid bond form included in the Contract Documents, unless the Owner elects to waive the use of the form provided, in its sole discretion.
2. Payment and Performance Bond. 100% of contract amount for all contracts \$25,000 or more.
- a. The Payment and Performance Bonds which the successful bidder as Contractor will be required to execute are included in the Contract Documents and should be carefully examined by the bidder. The Payment Bond shall be in an amount not less than 100 percent of the amount of the contract in accordance with Civil Code Section 3248. The successful bidder as Contractor will also be required to furnish a separate Performance Bond in the amount of 100 percent of the contract amount. Sufficient bonds shall be fully executed and returned to Owner with the executed Construction Agreement.

D. INSURANCE REQUIREMENTS:

1. Evidence of Insurance: Before the work is started, the Contractor shall forward to the District Certificates of Insurance and all the Contractual Liability coverage called for in the Contract Documents is in force, and specifically covers this particular Contract with the Owner, including the hold harmless requirements. In addition, the Certificates shall contain the following:
 - 1) "No cancellation of this policy or endorsement of same shall be effective until; until the thirtieth (30th) day following the receipt of notice of such cancellation of the policy or endorsements by the Owner."
 - 2) Certificates of Insurance shall contain transcripts from the policies authenticated by the proper office of the Insurer, evidencing in particular those insured, the extent of the insurance, the location of and the operations to which the insurance applies, the expiration date and the thirty (30) day NOTICE OF CANCELLATION CLAUSE.
 - 3) Acceptance of the Certificates of Insurance shall not relieve or decrease the liability of the Contractor.
 - 4) In the absence of contrary written instructions from the District, the Contractor at the Contractor's expense, shall obtain and maintain insurance at all times during the prosecution of the Contract, in companies and through agencies approved by the District, and with limits not less than those stated hereinafter.
 - 5) The Contractor shall not commence work under this Contract until he has obtained and paid for all insurance required herein and such insurance has been approved by the Owner, nor shall the Contractor allow any Subcontractor to commence work on his Subcontract until such insurance required of the Subcontractor has been so obtained and approved.
2. Provide the following items with evidence of insurance for all insurance policies for this project: The insurance required must be written by a Best Key Rating Guide "A" or better

rated carrier admitted to write insurance in the state where the work is located at the time the policy is issued.

3. Indemnification

- a. To the fullest extent permitted by law, the Contractor shall indemnify and hold harmless the District and the Consultants and their employees from and against all claims, damages, losses and expenses, including attorneys' fees arising out of or resulting from the performance of the Work, provided that any such claim, damage, loss of expense is attributable to bodily injury to or destruction of tangible property (other than the Work itself) including the loss of use resulting there from but only to the extent caused in whole or in part by any negligent act or omission of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by a party indemnified hereunder.
- b. In any and all claims against the District or the Consultants, or any of their employees by any employee of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, the indemnification obligation under this Paragraph shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for the Contractor or by any Subcontractor under workers compensation acts, disability benefit acts or other employee benefit acts.
- c. The obligations of the Contractor under this Paragraph shall not extend to the liability of the consultants or any of their agents or employees arising out of 1) The preparation or approval of maps, drawings, opinions, reports, surveys, change orders, designs or specifications, or, 2) the giving of or the failure to give directions or instructions by the consultants or any of their agents or employees, provided such giving or failure to give is the primary cause of the injury or damage.
- d. The Contractor to name the District, the consultants, its agents and employees as additional insured on the Contractor's policy or policies of comprehensive general liability insurance. Such insurance shall include products and completed operations and contractual liability coverages, shall be primary and non-contributing with any insurance maintained by consultants, or its agents and employees, and shall provide that the Consultant be given thirty days, unqualified written notice prior to any cancellation thereof.

4. Worker's Compensation Insurance

Contractor shall provide, during the term of this Contract, Worker's Compensation Insurance for all of his employees engaged in Work under this Contract, on or at the site of the project, and in case any of his work is sublet, Contractor shall require the Subcontractor to provide Worker's Compensation Insurance for all of his employees. Any class of employee or employees not covered by a Subcontractor's insurance shall be covered by the Contractor's insurance. In case any class of employees engaged in work under this Contract, on or at the site of the project, is not protected under the Worker's Compensation laws, Contractor shall provide or cause a Subcontractor to provide, adequate insurance coverage for the protection of those employees not otherwise protected. Contractor shall file, with the Owner, certificates of insurance.

- a) The Worker's Compensation Insurance shall be written by a company California admitted in the State of California and shall be written for not less than the following, as established by the Owner, or greater if required by law.
- b) Provide employer's liability endorsements:
 - 1) State workers' compensation statutory benefits - policy limits of not less than \$1,000,000.00.
 - 2) Employer's Liability - policy limits of not less than \$1,000,000.00.

5. Comprehensive General Liability Insurance

Commercial General Liability Insurance in Contractor's name, with personal injury limits indicated herein for combined Single Limit per occurrence coverage and annual aggregate. The policy is to be on a Comprehensive General Liability form and must include Contractual

Liability endorsed to specifically cover an Indemnity Agreement contained in the Contract. The Comprehensive General Liability coverage may be provided on an "occurrence" form or a "claims made" basis. If the coverage is on a "claims made" basis, the policy shall provide for a non-cancelable 5 year extended reporting period.

- a) The Contractor shall carry such public liability and property damage insurance that will protect the Contractor, Owner, Architect and Engineers from claims for damages for bodily injury, including accidental death, as well as for claims for property damages, which may arise from operations under the contract whether such operations be by the Contractor or by any Subcontractor or anyone directly or indirectly employed by either party. The limits of coverage shall be as stated herein.
 - b) In the event that any suits, actions, or claims are brought against the Owner, Architect, and/or Architect's Consultants, money equal to the "claim amount may be withheld from payments due the Contractor under and by virtue of this contract as may be considered necessary by the Owner for such purpose. Money due the Contractor will not be withheld when the Contractor produces satisfactory evidence that adequate public liability and property damage insurance has been obtained.
 - c) The policy shall include coverage for the following:
 - 1) Premises - operations
 - 2) Contractual liability
 - 3) Products
 - 4) Completed operations
 - 5) Broad form PD and including X, C and U coverage
 - 6) Personal injury
 - 7) Owners, contractor's protective
6. Automobile Liability Insurance: Automobile Liability Insurance with an Employer's Non-Ownership Liability Endorsement in the Contractor's name. Limits of liability shall not be less than amount indicated herein for Combined Single Limit per occurrence. Provide CSL, BI and PD coverage for owned, non-owned and hired autos.
- a) Provide owned, non-owned and hired automobile insurance endorsement.
7. Insurance Schedule
- a) Worker's Compensation Insurance per State of California policy limits of not less than \$1,000,000.00.
 - 1) Employer's Liability Endorsement \$1,000,000 min.
 - b) Comprehensive General Liability:
 - 1) Combined single limits for bodily injury and property damage:
\$1,000,000 - Each Occurrence
\$2,000,000 - Annual Aggregate
 - 2) Personal Injury, with Employment Exclusion deleted.
 - 3) Include coverage of the following:
 - i) Premises - operations
 - ii) Contractual liability
 - iii) Products
 - iv) Completed operations
 - v) Broad form PD and including X, C and U coverage
 - vi) Personal injury
 - vii) Owners, contractors protective
- E. ASBESTOS-CONTAINING PRODUCTS:
1. Contractor agrees that asbestos-containing products or materials will not be used or substituted in performing work under the Agreement.
 2. At the completion of work under this Agreement, Contractor will certify in writing to the Owner that, to the best of Contractor's knowledge, no asbestos-containing products or materials were used or substituted in performing work under the Agreement.

F. PCB-CONTAINING PRODUCTS & LEAD PLUMBING ITEMS:

1. Contractor agrees that lead plumbing domestic water items, asbestos, PCB, -containing products or materials will not be used or substituted in performing work under the Agreement.
 2. At the completion of work under this Agreement, Contractor will certify in writing to the Owner that, to the best of Contractor's knowledge, no lead plumbing domestic water items, asbestos/PCB-containing products or materials were used or substituted in performing work under the Agreement.
- G. PREVAILING WAGE RATES AND APPRENTICESHIP REQUIREMENTS – All proposals that exceed \$1,000 shall be prevailing wage.
1. Wages and Employer Payments:
 - a) The general prevailing wage rates and employer payments for Health and Welfare, Pension, Vacation and similar purposes in the county in which the work is to be done shall be in accordance with the Labor Code of the State of California, Section 1770, et seq.
 - b) Copies of all collective bargaining agreements relating to the work as set forth in the aforementioned Labor Code are on file and are available for inspection in the Office of the Division of Labor Statistics and Research of the Department of Industrial Relations.
 - c) Employer payments as defined in Section 1773.1 of the Labor Code are to be paid in accordance with the terms of the collective bargaining agreement applicable to the type of classification of the workmen employed on the project and shall be the prevailing wage rate of the county in which the work is to be performed. Overtime shall be paid for the hours worked in excess of the working day and for time worked on Saturdays, Sundays and the seven (7) holidays which are to-wit:
 New Year's Day, Memorial Day, July Fourth,
 Labor Day, Veteran's Day, Thanksgiving Day
 and Christmas.
 The Contractor and any subcontractor under him shall comply with the requirements of Sections 1773.3, 1777.5, 1776 and 1777.6 in the employment of apprentices.
 - 1) The predetermined (double asterisk) changes are no longer a part of the general prevailing rates of per diem wages. The rates at the time of the proposal advertisement date of a project will remain in effect for the life of project.
 - 2) The definition of prevailing rate states that when there is no single rate paid to a majority of workers, then the prevailing rate is a weighted average.
 - d) Not less than the general prevailing wage rate for each classification of work State or Federal which is higher shall be paid by the general contractor and all subcontractors under him shall be paid to all laborers, worker and mechanics employed in the execution of such contract or subcontract there under, including rates for overtime and general holidays in the locality in which the work is to be performed.
 - e) The Contractor and all subcontractors under him shall make travel and subsistence payments to each workman needed to execute all the work as such travel and subsistence payments are defined in the applicable collective bargaining agreements filed in accordance with Section 1773.8 of the Labor Code.
 2. Eight Hour Day: Contractor shall not permit any person employed by him to work overtime other than pursuant to express provisions of Section 1810 of the California Labor Code.
 3. Records of Hours Worked and Citizenship: The Contractor shall maintain records of the hours worked by his employees and their citizenship and they shall be open at all times for inspection by the County, Client and/or the Division of Labor Statistics and Law Enforcement, in accordance with Sections 1814 and 1552 of the California Labor Code.
 - a) The General Contractor shall maintain all certified payroll documents at their office. Copies shall be provided to anyone who provides a request and Owner approves

that request. Contractor shall provide copies within ten (10) days of approved request. Contractor shall provide copies, shipping cost, and all other related cost to provide this information at no cost to Owner. Contractor shall maintain certified payroll documents for seven (7) years after Notice of Completion.

4. Penalties: The Contractor shall forfeit as a penalty to said Owner, Fifty Dollars (\$50.00) for each laborer, workman or mechanic paid less than the above stipulated rates for any work under this Contract by him or any Subcontractor under him.
5. Enforcement and Verification off Requirements:
 - a) The records by the Contractor may be checked periodically by an independent enforcement agency to verify compliance with the labor codes and related items.
 - b) Jobsite interviews may be conducted periodically throughout the duration of the project. The Contractor shall allow access to the project and access to workers during working hours to confirm prevailing wage rates and apprenticeship requirements are followed.
 - c) Prior to executing the agreement, the Contractor shall provide verification of enrollment in an apprenticeship program per Sections 1773.3, 1777.5, 1776 and 1777.6 within the last 12 months.

H. Contractor License and DIR Registration Required.

To perform the work required for this project, Bidder must possess the type of contractor's license specified in the Notice to Proposers (Request for Proposal), and must be registered with the Department of Industrial Relations (DIR) as a public works contractor. Contractor registration can be accomplished through the portal <https://efiling.dir.ca.gov/PWCR/>. No CONTRACTOR or subcontractor shall be qualified to bid on, be listed in a bid proposal, subject to the requirements of § 4104 of the Public Contract Code, for a public works project (submitted on or after March 1, 2015) unless currently registered with the DIR and qualified to perform public work pursuant to Labor Code § 1725.5. No CONTRACTOR or subcontractor may be awarded a contract for public work on a public works project (awarded after April 1, 2015) unless registered with the DIR.

I. AWARD

District shall issue a purchase order, which shall be the notice to proceed. This will be issued only after receipt of required documents.

J. PRELIMINARY NOTICE:

Preliminary Notices must be filed with the Owner with a copy mailed to both the Consultants and the Contractor.

CONTRACTOR'S CERTIFICATE REGARDING WORKER'S COMPENSATION:

Labor Code Section 3700 provides:

"Every employer except the State and all political subdivision or institutions thereof, shall secure the payment of compensation in one or more of the following ways:

"(a) By being insured against liability to pay compensation in one or more insurers duly authorized to write compensation insurance in this State.

"(b) By securing from the Director of Industrial Relations a certificate of consent to self-insure, which may be given upon furnishing proof satisfactory to the Director of Industrial Relations of ability to self-insure and to pay any compensation that may become due to his employees."

I am aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for Workers Compensation or to undertake self-insurance in accordance with the provisions of that Code, and I will comply with those provisions before commencing the performance of the work of this contract.

CONTRACTOR:

By (type or print) Title Dated

(In accordance with Article 5 [commencing at Section 1860], Chapter 1, Part 7, Division 2 of the Labor Code, this certificate must be signed and filed with the awarding body prior to performing any work under this contract.)

NON-COLLUSION AFFIDAVIT:

State of California)
) ss.
County of _____)

_____, being duly sworn, deposes and says:

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

(Firm Name)

(Printed Name - Authorized Agent)

(Signature - Authorized Agent)

Subscribed and sworn to before me on _____, 20 _____.

Notary Public

NOTARY SEAL

SUBCONTRACTOR LIST:

Pursuant to the Provisions of the Public Contracts Code Sections 4100 to 4107 inclusive, every proposer shall set forth the name and location of the place of business of each subcontractor who will perform work or labor in or about the construction of the work or improvement in an amount in excess of one-half of one percent (1/2 of 1%) of the Proposers total proposal. If a Contractor is not listed and the work is more than one-half of one percent (1/2 of 1%) of the Proposers total proposal, he agrees to perform that portion himself. The following is the list of subcontractors:

<u>PORTION OF WORK</u>	<u>SUBCONTRACTOR</u>	<u>LOCATION OF BUSINESS</u>

I declare, under penalty of perjury, that information provided, and representations made in this proposal are true and correct and that this declaration was executed on _____, at _____, _____, California. (date) (city) (county)

Respectfully submitted,

Name of Firm

Individual, Partnership, Corp.

By _____

Address _____

Corporate Seal
If Applicable

Phone(_____) _____

Fax(_____) _____

License Type & Number/Exp. date

No proposal is valid unless signed by the person making the proposal.

** State whether your firm is a corporation, a co-partnership, private individual, or individuals, doing business under a firm name. If the proposer is a partnership, the proposal should be signed with the partnership name and by one of the authorized partners. If the proposer is a corporation, it should be signed by a person authorized to execute proposals on behalf of the corporation.

* * *

4.0 BID BOND

Be advised that we, _____
as Principal ("Principal") and _____

_____ a corporation duly licensed to transact business under the laws of the State of California as Surety ("Surety") are firmly bound to **WEST HILLS COMMUNITY COLLEGE DISTRICT** as Obligee ("Obligee") in the sum

of \$ _____ for the payment of which the Principal and the Surety bind ourselves, our heirs, executors, administrators, successors, and assigns, jointly and severally, by this Bond.

The principal has submitted a proposal for _____
(list project on Proposal)

The condition of our obligation is this: if the Principal is awarded the contract upon its proposal, and shall, within the required number of days after the notice of award, execute a contract with the Obligee in accordance with the contract documents, submit the required payment and performance bonds, and provide all other required documents, then this obligation shall be null and void; but in the event that the Principal fails and/or refuses to execute and deliver those documents, this bond will be charged with the costs of the damages experienced by the Obligee as a result of that refusal, including but not limited to, publication costs, the difference in money between the amount of the bid of the Principal and the amount for which the Obligee may legally contract with another party to perform the work if the amount is in excess of the former; building lease or rental costs, transportation costs, professional service costs, and additional salary costs that result from the delay due to the Principal's default on the awarded contract. In no event, however, shall the Surety's liability exceed the penal sum indicated above.

The Surety, for value received, stipulates and agrees that its obligations and its bond shall not be impaired or affected by an extension of the time within which the Obligee may accept such bid; and Surety waives notice of any time extension.

Dated: _____
PRINCIPAL
By: _____
Title: _____

Dated: _____
SURETY
By: _____
Title: _____

5.0 GENERAL CONDITIONS OF AGREEMENT

- 1) The district will issue a Purchase Order for all work included in this Request for Proposal based on the Contractor's proposal to do certain work for the said Owner, specified and described in certain drawings and specifications, and entitled on the Bid Proposal, in strict accordance with drawings and specifications prepared and attached to RFP.
- 2) Whereas, the Contractor, before signing the enclosed proposal, has carefully read and examined in connection herewith said proposal and specifications and has carefully examined the site where said work is to be done, and has investigated the character of such work and the materials required to be furnished, and by reason of such reading, examination and investigation, the said Contractor agrees that he thoroughly understands the intent and meaning of this proposal and all component parts of said proposal and the requirements, covenants, stipulations and restrictions thereof.
- 3) In consideration of the promises and of the payments hereinafter to be made by the Owner to and on account of said Contractor, and the understanding of said Contractor to do said work the College and Contractor agree that:
 - a) This Contractor shall receive and accept the sum on proposal herein submitted, as full compensation for furnishing all materials and doing all the work contemplated and embraced in this Contract, and for furnishing all necessary tools, machinery, implements, apparatus and other means of construction; also all loss or damage arising out of the nature of the work to be done under said specifications, or from the action of the elements, or from any unforeseen difficulties or obstructions which may arise or be encountered during the progress of said work, and before the acceptance thereof by said Owner, and shall be responsible for the consequences of his own negligence or carelessness or discontinuance of the work, and for well and faithfully completing the work in the manner and according to the drawings and specifications and all requirements of the College and any and all parties having jurisdiction there over, for the whole thereof, the following sum which represents the Contract Price.
 - b) Payments: The Owner agrees, in consideration of the performance of this Contract, to pay the Contractor in the following manner:
 - i) Payments will be made only on the certificate of the Owners field representative.
 - ii) Monthly payments shall be made to the Contractor in amounts equal to ninety-five percent (95%) of the estimated value of the work done and the materials furnished and incorporated in the work during the month preceding the date upon which such value is estimated plus ninety-five percent (95%) of the estimated value of all materials which, on the date of estimation of value, are suitably stored on the site for incorporation into the work; provided that no such monthly payment, or payment of any kind, shall theretofore have been made for any such work done or materials furnished and incorporated or materials suitably stored on the site. The aforesaid estimation of value shall be made by the Owners Representative and noted by him upon the certificates furnished by him pursuant to paragraphs herein.
 - iii) Upon substantial completion of the work, a sum sufficient to increase the total payments to ninety-five percent (95%) of the Contract Price, less an amount determined by Owner to be adequate to complete any unfurnished part of the work by another Contractor should the work not be completed within a reasonable time established by the Owner.
 - iv) The final payment shall be made thirty-five (35) days after receipt of the recorded Notice of Completion date, provided that: The Contractor shall furnished satisfactory evidence that all claims for labor and materials have been paid and that no claims shall have been presented to the Owner by any person or persons based upon any act or omission of the Contractor, and no Stop Notices have been filed against said work or the property whereon it was done.
 - (1) No certificates given or payments made on account of any Contract shall constitute an acceptance of any equipment, material or work which may subsequently be found to be defective.
 - c) Time of Completion. The Contractor agrees to commence the work within ten (10) calendar days from the date of the notice to proceed and/or purchase order. Failure to obtain approval of the required documents, within the allotted time, shall not be cause for extension of the time of construction as set forth hereafter.

- i) The Contractor further agrees to construct and execute all of the work described in said drawings, specifications, proposals, addenda and any and all other requirements, covenants, stipulations and restrictions, within the timeframe specified on Document 3.0 Proposal.
- ii) Both parties agree that the aforementioned stipulated contract period to be a reasonable time scale for completion of the work and Contractor will provide best endeavors to complete the work within the contract period.
- iii) If the Contractor shall neglect, fail or refuse to complete the work within the time herein specified, then the contractor does hereby agree, as a part consideration for awarding of this Contract to pay to the Owner the sum of:
Fifty Dollars - No Cents DOLLARS (\$50.00) per day plus such additional costs as may be incurred by the College because of such delays, not as a penalty but as liquidated damages for such breach of Contract as hereinafter set forth for each and every day that the Contractor shall be in default after the time stipulated in the Contract for completing the work.
- iv) The said amount is fixed and agreed upon by and between the Contractor and the Owner because of the impracticability and extreme difficulty of fixing and ascertaining the actual damages the Owner would in such event sustain, and said amount is agreed to be the amount of damages which the Owner would sustain and said amounts shall be retained from time to time by the Owner from the current periodical estimates.
- v) It is further agreed that time is the essence of each and every portion of this Contract and of the specifications wherein a definite and certain length of time is fixed for the performance of any act whatsoever; and where under the Contract an additional time is allowed for the completion of any work, the new time limit fixed by such extension shall be of the essence of this Contract. Provided, that the Contractor shall not be charged with liquidated damages or any excess cost when the delay in completion of the work is due.
 - (1) To any preference, priority or allocation order duly issued by the Government.
 - (2) To unforeseeable cause beyond the control and without the fault or negligence of the Contractor, including but not restricted to acts of God, or of the public enemy, acts of the Owner, acts of another Contractor in the performance of the Contract with the Owner, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, unusually severe weather, and
 - (3) To any delays of subcontractors occasioned by any of the causes specified in subsections (1) and (2) of herein. Provided, further, that the Contractor shall, within seven (7) days from the beginning of such delay, notify the Owner, in writing , of the causes of delay, who shall ascertain the facts and extent of the delay and notify the Contractor within a reasonable time of its decision in the matter.
- d) Drawings and Specifications. This Contract, the drawings and the specifications have been prepared, and are intended to supplement one another. The drawings and specifications shall be deemed by this reference to be incorporated within this Contract, the drawings shall be deemed by this reference to be incorporated within the specifications, and the specifications shall be deemed by this reference to be incorporated with the drawings. In the event a conflict is found to exist between the drawings and specifications, the College shall interpret. In the event that the drawings and specifications, or either of them shall be found to conflict with this Contract, then this Contract shall be govern. Omissions from this Contract of items of provisions present in the specifications or drawings or either of them shall not be deemed a conflict within the meaning of this Article.
- e) Changes. Should the Owner, at any time during the progress of the work desire any alterations, or deviations in, or additions to , or omissions from the Contract or the drawings or specifications, said Owner, or representative thereof, shall be at liberty to order them, in writing, and the same shall in no way affect or make void this Contract, but the amount thereof shall be added to, or deducted from, the amount of the Contract Price aforesaid, as the case may be, by a fair and reasonable valuation. This Contract, subject to the provisions of Article II (a) hereof, shall be deemed completed when the work is finished in accordance with the original drawings and specifications, as amended by such changes, whatever may be the nature or extent thereof.
 - i) No such changes, whatever may be the nature, or modification shall release or exonerate any surety or sureties upon any guarantee or bond given in connection with this Contract, if required.

- ii) Rules of Practice: The rule of practice to be observed in this Contract shall be that upon the demand of either the Owner or the Contractor, the character or valuation of any and all changes, omissions, or extra work shall be agreed upon and fixed in writing, signed by the Owner and the Contractor, prior to execution.
- f) Acceptance of Work. The payment of the progress payments by the Owner shall not be construed as an absolute acceptance of the work done up to the time of such payments, except as to such matters as are open and obvious, but the entire work, and at the time when it shall be claimed by the Contractor that the Contract and work is completed. Liability under the bonds is to continue for one (1) year from the date of acceptance and bonds will not be released until such date.
- g) Failure to provide workmen and materials. If the Contractor at any time during the progress of the work should refuse or neglect, without the fault of the Owner, to supply sufficient amount of materials or enough workmen to complete the Contract within the time herein set forth, due allowance being made for the contingencies provided for herein, for a period of more than seven (7) days after having been notified by the Owner in writing to furnish the same, the Owner shall have the power to furnish and provide said materials and/or workmen to finish the said work, and the reasonable expense thereof shall be deducted from the amount of the Contract Price.
- h) Penalties. This Contractor shall forfeit, as a penalty to the said Owner, the sum of fifty dollars (\$50.00) for each laborer, workman, or mechanic employed in the execution of this Contract, or any sub-contractor under him, for each calendar day during which such laborer, workman or mechanic is required or permitted to labor more than eight (8) hours in violation of Section 1810-1811, Chapter One, of Division Two, Part Seven of the Labor Code of the State of California, and said Owner, when making payments of money due under this Contract, shall withhold and retain there from all sums and amounts which have been forfeited pursuant to the herein said stipulation.
- i) Insurance and Bonds: Insurances and bonds, as set forth in the supporting contract documents, shall be maintained in effect during the period of this Contract.
- j) Relations to Bid Proposals: If proposal is accepted by owner, be it further stipulated and agreed that said Owner does promise and agree to employ the said Contractor to provide the materials and do the work according to the terms and conditions herein contained and referred to, for the prices aforesaid, and herein contracts to pay the same at the time, in the manner and upon the conditions set forth above; and the said parties for themselves, their heirs, executors, administrators, successors, and assigns, do hereby agree to the full performance of the covenants herein contained. It is further agreed by and between the parties hereto that should there be any conflict between the terms of this instrument and the bid proposal of said Contract, then this instrument shall control and nothing herein shall be considered as an acceptance of the said terms of said proposal conflicting herewith.
- k) Asbestos/PCB-containing products and lead plumbing items: Contractor agrees that lead plumbing domestic water items, asbestos, PCB, -containing products or materials will not be used or substituted in performing work under the Agreement. At the completion of work under the Agreement, Contractor will certify in writing to the Owner that to the best of Contractor's knowledge, no lead plumbing domestic water items, asbestos/PCB-containing products or materials were used or substituted in performing work under the Agreement.
- l) Compliance with air pollution and storm water prevention control rules: Contractor shall comply with all air pollution control rules, regulations, ordinances, and statutes which apply to any work performed pursuant to the Contract, including any air pollution control rules, regulations, ordinances, and statutes specified in Section 11017 of the Government Code, as well as local requirements, County, City, local Air Pollution Control Districts and Storm Water Prevention Districts. Contractor shall require all subcontractors to abide by these items.
- m) Contractor-Employee requirements: By submitting proposal, the Contractor certifies he is aware of the provisions of section 3700 of the Labor Code which require every employer to be insured against liability for workmen's compensation or to undertake self-insurance in accordance with the provisions of that code, and that he will comply with such provisions before commencing the performance of the work of this Contract.
 - i) In accordance with the provisions of Section 3700 of the Labor Code, every contractor will be required to secure payment of compensation to his employees.
 - ii) The Contractor and Subcontractors under him shall comply with the provisions of Division 2, Part

- 7, Chapter 1, Article 2, Sections 1770-1780 with particular reference to the employment and use of apprentices and other provisions that require him to make travel and subsistence payments to each workman needed to execute the work, as such collective bargaining agreements filed in accordance with the Labor Code, and to pay not less than the minimum per diem wages as determined by the Director of the Department of Industrial Relations, on file in the principal office of the Owner.
- iii) Special attention is directed to Sections 1777.5, 1777.6 and 1777.7 of the California Labor Code and Title 8, California Code of Regulations Section 200 et. seq. Each contractor and/or subcontractor must, prior to commencement of the public works contract, contact the Division of Apprenticeship Standards, 455 Golden Gate Avenue, San Francisco, or one of its branch offices regarding apprentices and specifically the required ratio there under. Responsibility for compliance with this section lies with the prime Contractor. During the performance of this Contract, the Contractor will not discriminate against any employee or applicant for employment because of race, religion, color, sex or national origin.
 - n) Notices: All notices herein provided to be given or which may be given by either party to the other shall be deemed to have been fully given when made in writing and deposited with the United States Postal Service, Registered or Certified, and postage prepaid and addressed as follows:
 - i) Owner, person and address on title sheet of RFP.
 - ii) Contractor, person and address on proposal submitted by contractor herein.
 - iii) The address to which the notices shall or may be mailed as aforesaid to either party shall or may be changed by written notice given by such party to the other, as hereinbefore provided, but nothing herein contained shall preclude the giving of any such notice by personal service.

6.0 PROJECT SCOPE

A. PROJECT DESCRIPTION:

PART 1 - GENERAL

1.1. SUMMARY

The West Hills Community College District (WHCCD), West Hills College Coalinga has a requirement to remove and replace the HVAC Controls on Buildings A, B, G, H, N, J, and P. The Contractor will include all labor, materials, equipment and necessary rigging to complete the work located at 300 Cherry Lane, Coalinga, CA 93210. To this end, WHCCD, West Hills College Coalinga requires quotations for a licensed contractor to complete the proposed modifications.

Intent:

Requirements in this SOW serve as a direction to the Contractor for the HVAC Controls replacement in Buildings A, B, G, H, N, J, and P at West Hills College Coalinga. The Contractor shall perform all services in accordance with professional standards of skill, care and diligence adhered to by reputable, first class international firms and shall conform to generally accepted professional practices and to all applicable codes.

B. WORK SEQUENCE :

1. Schedule building shutdown with M&O Director. All work to each building to be performed as scheduled so as not to interrupt any instruction.
2. The Work will be conducted in one phase to provide the least possible interference to the activities of the Owner's personnel and to permit an orderly transfer of personnel and equipment to the new facilities. Installation must be complete when building is vacant and/or a Friday afternoon. Contractor may have weekend access if so desired.

C. CONTRACTOR USE OF PREMISES:

1. General: Limit use of the premises to construction activities in areas indicated; allow for Owner occupancy and use by the public.
 - a. Confine operations to areas within Contract limits indicated. Portions of the site beyond areas in which construction operations are indicated are not to be disturbed.
 - b. Keep driveways and entrances serving the premises clear and available to the Owner and the Owner's employees at all times. Do not use these areas for parking or storage of materials. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on site.
2. Use of the Existing Building: Maintain the existing indoor building conditions throughout the replacement period. Repair damage caused by construction operations. Take all precautions necessary to protect the building and its occupants during the construction period.

D. OWNER OCCUPANCY:

1. Full Owner Occupancy: The Owner will occupy the site and existing building during the entire construction period. Cooperate with the Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with the Owner's operations.
- 2.

1. Contractor to inspect project site and inspect existing conditions/utilities.
2. Scheduling of work to be coordinated with college M/O Director.
3. Provide all necessary labor, tools and equipment to complete work within time frame stated in contract.
4. Contractor to inform Owner one (1) week before work is completed to schedule testing and inspection.
5. Work areas shall be cleaned / cleared on a daily basis. All construction debris to be removed from site upon completion of work by contractor.
6. Please use section 7.0 Attachments for specifications for this project

F. SCOPE OF WORK:

Coordinate schedule with M&O Director once materials have been ordered so a lead time is identified. Existing Conduit, Valves, Actuators, Enclosures may be reused if in good repair. New wire will be required.

Building #1 (G)

- (2) Air Handling Units and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused

Building #2 (A and B)

- (1) Langate Router and Gateway
- (1) Air Handling Unit and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Duct Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused
- (2) Split System
 - Control Modules
 - Air Temperature Sensors
 - Zone Sensors
- (6) VAV Boxes
 - Controllers
 - DAT
 - Zone Temperature Sensors

Building #4 (H)

- (3) Air Handling Units and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused

Building #5 (N)

- Langate Router and Gateway
- (3) Air Handling Units and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused
- (1) Heat Pump
 - Control Modules
 - Air Temperature Sensors
 - Zone Sensors

Building #6 (J)

- (4) Air Handling Units and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused

Building #8 (P)

- (4) Air Handling Units and (1) Lighting Controller
 - Control Modules
 - Filter Pressure Sensor
 - Air Temperature Sensors
 - Zone Sensors
 - All other End Devices may be reused

CONTRACTOR PROVISIONS:

The Contractor shall supply everything necessary for the execution and completion of the work including Site preparation and installation performance shall be in accordance with all building codes and standards

WORKING HOURS:

Working hours are to be 6am to 6pm. No work is to take place outside these hours unless Director M&O has given agreement.

SITE PREPARATION AND CLEANING UP

The Contractor shall at all times keep the work area, including storage areas, free from accumulations of waste materials. Before completing the work, the Contractor shall remove the work and premises any rubbish, tools, scaffolding, equipment, and materials that are not the property of the College. Unsightly materials and debris including excess soil, garbage, and equipment should be removed as required; while materials should be scheduled for delivery only as required for immediate use.

7.0 ATTACHMENTS

Section 23 09
00.docx

Specification Section: 23 09 00

-----End of Document-----

Section 23 09 00

Instrumentation and Control for HVAC

**WEST HILLS COLLEGE- EMCS UPGRADES
WHCCD COALINGA BUILDINGS A, B, G, H, J, P**

Contents

23 09 23 Direct-Digital Control System for HVAC	1
PART 1: GENERAL	1
Section Includes	1
Products Furnished but Not Installed Under This Section	2
Products Installed but Not Furnished Under This Section	2
Products Not Furnished or Installed Under but Integrated with the Work of This Section	2
Related Sections	2
Description	2
Approved BMS Systems	3
Quality Assurance	3
Codes and Standards	3
System Performance	3
Submittals	6
Warranty	10
Ownership of Proprietary Material	10
PART 2: PRODUCTS	12
Section Includes	12
Materials	13
Communication	13
Operator Interface	14
Controller Software	30
Controllers	32
Input and Output Interface	36
Power Supplies and Line Filtering	38
Auxiliary Control Devices	39
Local Control Panels	51
Wiring and Raceways	51
Fiber Optic Cable System	51
PART 3: EXECUTION	53
Section Includes	53
Examination	54
Protection	54
Coordination	54
General Workmanship	55
Field Quality Control	55
Wiring	56
Communication Wiring	57
Fiber Optic Cable	58
Installation of Sensors	58
Flow Switch Installation	59
Actuators	59
Warning Labels	60
Identification of Hardware and Wiring	60

Controllers	60
Programming	61
Control System Checkout and Testing	62
Control System Demonstration and Acceptance	62
Cleaning	64
Training	64
Sequences of Operation	65
Control Valve Installation	65
Control Damper Installation	66
Smoke Damper Installation	66
Duct Smoke Detection	66
Start-Up and Checkout Procedures	67
23 09 93 Sequence of Operations for HVAC Controls	68
PART 1: GENERAL	68
APPENDIX A: Definitions	69
APPENDIX B: Abbreviations	73

23 09 23 Direct-Digital Control System for HVAC

PART 1: GENERAL

- 1.0 Section Includes**
- 1.1 Products Furnished but Not Installed Under This Section**
- 1.2 Products Installed but Not Furnished Under This Section**
- 1.3 Products Not Furnished or Installed Under but Integrated with the Work of This Section**
- 1.4 Related Sections**
- 1.5 Description**
- 1.6 Approved BMS Systems**
- 1.7 Quality Assurance**
- 1.8 Codes and Standards**
- 1.9 System Performance**
- 1.10 Submittals**
- 1.11 Warranty**
- 1.12 Ownership of Proprietary Material**

1.1 Products Furnished but Not Installed Under This Section

- A. None

1.2 Products Installed but Not Furnished Under This Section

- A. None

1.3 Products Not Furnished or Installed Under but Integrated with the Work of This Section

- A. None
- B. Communications with Third Party Equipment:

1.4 Related Sections

1.5 Description

- A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.
- B. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner’s local area network, and (at the owner’s discretion) over the Internet.
- C. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.
- D. System shall use the BACnet protocol for communication between the control modules and web server. Communication between the web server and the user’s browser shall be HTTP or HTTPS protocol utilizing HTML5. Use of Adobe Flash technology is not acceptable.

1.6 Approved BMS Systems

- A. The following are approved control system suppliers, manufacturers, and product lines:

Supplier	Manufacturer	Product Line
Pacific West Controls, Inc.	Automated Logic Corporation	WebCTRL
Air Systems, Inc.	Automated Logic Corporation	WebCTRL
American Building Automation, Inc.	Automated Logic Corporation	WebCTRL

The above list does not indicate order of preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

- B. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.
- C. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.7 Quality Assurance

- A. Installer and Manufacturer Qualifications
 - 1. Installer shall have an established working relationship with the Control System Manufacturer and have, as a minimum, 5 years demonstrated experience with installation and support of the manufacturer's product.
 - 2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

1.8 Codes and Standards

- A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:
 - 1. National Electric Code (NEC)
 - 2. International Building Code (IBC)
 - a. Section 719 Ducts and Air Transfer Openings
 - b. Section 907 Fire Alarm and Detection Systems
 - c. Section 909 Smoke Control Systems
 - d. Chapter 28 Mechanical
 - 3. International Mechanical Code (IMC)
 - 4. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.9 System Performance

- A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for display through the user's web browser.
 - 1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.

2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the browser within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each user, connected to network accessing the system through their browser (workstation), shall receive alarms within 5 seconds of one another.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table-1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)
Water Temperature	±0.5°C (±1°F)
Delta-T	±0.15° (±0.25°F)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO ₂)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale

Note 2: For both absolute and differential pressure

Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.0°C (±2.0°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.10 Submittals

- A. Product Data and Shop Drawings: The contractor shall provide shop drawings and product data on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide submittal data in a digital format on suitable digital media such as a USB drive. The submittal data shall be in standard Microsoft (Word, Excel, etc.) or PDF file formats. The shop drawings shall be formatted to fit on 11" x 17" pages and hardware/software product data shall be formatted to fit on 8.5" x 11" pages. When manufacturer's cutsheets 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 drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware

- a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
- b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
 - i. Direct digital controllers (controller panels)
 - ii. Transducers and transmitters
 - iii. Sensors (including accuracy data)
 - iv. Actuators
 - v. Valves
 - vi. Relays and switches
 - vii. Control panels
 - viii. Power supplies
 - ix. Batteries
 - x. Operator interface equipment
 - xi. Wiring
- c. Wiring diagrams and layouts for each control panel. Show termination numbers.
- d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

- a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.

- b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
 - i. Central Processing Unit (CPU) or web server
 - ii. Monitors
 - iii. Keyboards
 - iv. Power supplies
 - v. Battery backups
 - vi. Interface equipment between CPU or server and control panels
 - vii. Operating System software – web server
 - viii. Color graphic software
 - ix. Third-party software
 - c. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
 - d. Network riser diagrams of wiring between central control unit and control panels.
3. Controlled Systems
- a. Riser diagrams showing control network layout, communication protocol, and wire types.
 - b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
 - c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
 - d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
 - e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
 - f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
 - g. A point list for each control system. List I/O points and software points required to provide specified sequence of operations. Indicate alarmed and trended points.
4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.

5. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.
- B. Project Documentation.
1. Upon completion of installation, submit record (as-built) documents for approval before final completion. Provide record documents in a digital format on suitable digital media such as a USB drive. The record documents shall be in standard Microsoft (Word, Excel, etc.) or PDF file formats except as noted below. Record documentation shall include the following:
 - a. Project Record Drawings.
 - b. Testing and Commissioning Reports and Checklists.
 - c. Operation and Maintenance (O&M) Manual.
 - d. As-built versions of submittal product data.
 - e. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 - f. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
 - g. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - h. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
 - i. Documentation of programs operating in the system and object database that can be viewed using technician software tools furnished with system.
 - j. Graphic files, programs, and database to be viewed using technician software tools furnished with system.
 - k. List of recommended spare parts with part numbers and suppliers.
 - l. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - m. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
 - n. Licenses, guarantees, and warranty documents for equipment and systems.
 - o. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 2. Load into the control system for access by the operator through any operator workstation closeout documentation. There shall be a menu or navigation tab to access the documentation. The documentation can be loaded into the control system in a pdf format. The following documentation shall be included:

- a. As-built control diagrams including wiring diagrams and sequences of operations for each controller/piece of equipment.
- b. All IOM data as follows:
 - i. IOM from each equipment manufacturer for each piece of equipment (AHUs, FCUs, Chillers, pumps etc.)
 - ii. IOM for each control module and end device installed in the system.
- C. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

1.11 Warranty

- A. Warrant work as follows:
 1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
 2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
 3. If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
 4. All Manufacturer's software/firmware for web server/workstation and controllers shall be updated to the latest versions that are available from the manufacturer within 30 days from the date of end of the warranty. These updates shall be installed and checked out before the end of the warranty.
 5. Provide updates to web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
 6. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired and factory recertified.

Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.12 Ownership of Proprietary Material

- A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:
1. Graphics
 2. Record drawings
 3. Database
 4. Application programming code
 5. Documentation

PART 2: PRODUCTS

- 2.0 Section Includes**
- 2.1 Materials**
- 2.2 Communication**
- 2.3 Operator Interface**
- 2.4 Controller Software**
- 2.5 Controllers**
- 2.6 Input and Output Interfaces**
- 2.7 Power Supplies and Line Filtering**
- 2.8 Local Control Panels**
- 2.9 Wiring and Raceways**

2.1 Materials

- A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 Communication

- A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.
- B. All IP based controllers shall be capable of providing IPv4 and IPv6 protocol standards as defined by the Internet Data Communications Standard.
- C. The owner shall furnish and install all communication media, connectors, repeaters and network switches/routers, and network devices necessary to provide a complete and workable high speed Ethernet communications/LAN network meeting or exceeding recommended control network specifications. The owner will provide an active IP/Ethernet port/drop within patch distance to each BMS server and BMS controller for connection to owner's LAN. BMS contractor will furnish and install all communications media, connectors, repeaters, switches/routers, and network devices necessary to provide a complete and workable serial network. Established network requirements such as labeling, testing, administration, and documentation must be provided to controls vendor prior to start of project.
- D. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.
- E. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
 - 1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
 - 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified sequences of operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

- F. Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.
- G. System shall be expandable to at least twice the required BACnet objects. No additional licensing/software fees shall be required to add controllers, associated devices, and wiring.
- H. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.
 - 1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.
 - 2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.
 - 3. For read or write requests, the system shall require user name and password authentication and shall support TLS (Transport Layer Security) or equivalent data encryption.
 - 4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.3 Operator Interface

- A. Operator Interface. The web server shall reside on high-speed network with building controllers. Web pages generated by this server shall be compatible with the latest versions of Microsoft Internet Explorer or Edge, Google Chrome, Mozilla Firefox, and Apple Safari browsers. Any of these supported browsers connected to the server shall be able to access all system information. Mobile devices shall be recognized by the web server and shall supply the appropriate system content as needed. The Operator Interface (web server with client devices) shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L. This includes the

ability to configure and/or reconfigure the system from the client device (change programs, graphics, labels, etc.).

- B. Communication. Web server and controllers shall communicate using BACnet protocol, including BACnet/SC. Web server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J. Communication between the web server and client (workstation) shall be HTTP or HTTPS protocol utilizing HTML5 language. Use of Adobe Flash in any part of the communication infrastructure is not acceptable.
- C. Hardware.
1. Web server and/or workstation. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The web server may also be configured in client/server fashion to accommodate a "workstation" definition. In "workstation" configuration, the workstation will also perform as a server supplying additional clients as needed. The following hardware requirements apply:
 - a. System storage shall have sufficient memory to accommodate:
 - i. All required system software.
 - ii. A DDC database to accommodate, as a minimum, twice the size of the delivered system database.
 - iii. One year of archival trend data based on the points specified to be trended at their specified trend intervals.
 - b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.
 - c. Minimum hardware configuration shall include the following:
 - i. Quad Core Processor
 - ii. 4-24 GB RAM (size dependent on size of system)
 - iii. 500 GB hard disk providing data at 3.0 Gb/sec (size dependent on historical data storage requirements)
 - iv. 16x DVD+/-RW drive
 - v. Qwerty Keyboard
 - vi. Optical Mouse
 - vii. 24-inch LED Color monitor with 75Hz refresh rate and 1080P resolution to provide a minimum screen resolution of 1920 x 1080 pixels.
 - viii. Serial (USB) and network communication ports, with cables as required for proper DDC system operation.

D. System Software.

1. Operating System. Web server shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the BMS manufacturer's minimum requirements for their software. Acceptable systems include Microsoft Windows 8.1 or 10, Windows Server 2012 R2 or 2016 or 2019 or 2020, Red Hat Enterprise Linux 8.3, or Ubuntu Desktop 18.04 or 20.04 LTS.
2. Security. The web server application shall support Transport Layer Security (TLS) 1.3 capable of encryption of up to 256 bit elliptical curve for transmitting private information over the Internet using HTTPS. Additionally, the web server shall have SHA-2 certificate support capability.
3. Database. System shall support any JDBC (Java DataBase Connectivity) compliant engine. This includes: MS SQL, My SQL, Apache Derby, PostgreSQL and Oracle.
4. The BMS system shall allow an unlimited number of concurrent users.
5. The BMS manufacturer shall provide all software and tools necessary to provide the following capabilities:
 - a. Create and/or edit any programming used in controllers
 - b. Create and/or edit any graphics used in the system
 - c. Software shall not be subscription based and be given to owner at time of turnover. If software is subscription based, manufacturer shall include 10 years of subscription service.
 - d. The owner shall have the ability to install software on a minimum of five (5) additional owner furnished computers without additional licenses or fees.
6. System Graphics. The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
 - a. Minimum graphics resolution shall be 1920 x 1080 for display of detailed system graphics.
 - b. Floor Plan Graphics. Floor plan graphics shall be capable of allowing the floor plan graphic to dynamically size relative to the end user's monitor resolution.
 - c. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click

- navigation between zones or equipment, and to edit setpoints and other specified parameters.
- d. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
 - e. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 - f. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, GIF, or SVG. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins.
7. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system used to create and modify graphics that are saved in the same formats as are used for system graphics.
 8. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
- E. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on a standard PC type personal computer with no limit on the number of copies that can be installed under the system license.
1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
 2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
 3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password.

4. On-Line Help. 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 the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security. Each operator shall be required to log on to the system with user name and password in order to view, edit, add, or delete data.
 - a. Operator Access. The user name and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System administrators shall also be able to vary and deny each operator's privileges based on the geographic location, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.
 - b. Password Policy Rules. System administrator shall invoke policies for minimum password strength, including number of characters, special characters and numbers, upper and lower case, etc.
 - c. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time period shall be user-adjustable.
 - d. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as required by sequences of operation. Alarms shall be BACnet alarm objects and shall use BACnet alarm services. BMS system shall be capable of assigning alarm sources to categories such as HVAC Critical, or HVAC General. The BMS shall include at a minimum HVAC and FDD categories. BMS system shall allow user to create custom alarm categories.

8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.
9. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send SMS text, and audibly annunciate.
10. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified by the sequences of operation. Trends shall be BACnet trend objects.
12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Audit and Security Detail. All users accessing the system shall have their actions recorded. Information recorded shall include:
 - a. Login/logout time and date
 - b. System modifications - with before and after values
 - c. Ability to report user activity based on individual and/or date and time.
15. Standard Reports. Furnish the following standard system reports:
 - a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
 - b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.

- c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
 - i. Alarm History.
 - ii. Trend Data. Operator shall be able to select trends to be logged.
16. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface. Operator shall be able to schedule reports to automatically run and be emailed to recipients on a recurring basis from the BMS system.
- F. Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.
 1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
 2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
 3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:
 - a. Language. Language shall be graphically based or English oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."
 - b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom

- programming code, and to copy blocks of code to a file library for reuse in other control programs.
- c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.
 - d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.
 - e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.
 - g. Variables. Operator shall be able to use variable values in program conditional statements and mathematical functions.
 - i. Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.
 - ii. System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

2.4 Controller Software

- A. All controller software applications shall reside and operate in the system controllers.
- B. All application software in controllers furnished by BMS manufacturer shall be editable through operator workstation, web browser interface, or workstation.

- C. Each controller furnished by BMS manufacturer shall have all of its local on board software applications backed up and saved to the BMS web server. In the event of a controller failure, the BMS server shall download backed up software applications to replacement controller. Controllers furnished by others and integrated into the BMS are not required to be backed up to BMS server.
- D. Furnish the following applications for building and energy management:
1. System Security.
 2. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:
 - a. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
 - b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
 - c. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.
 3. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.
 4. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.
 5. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.
 6. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.
 7. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.
 8. Demand Limiting.

- a. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.
 - b. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in in sequences of operation. When demand drops below adjustable levels, system shall restore loads as specified.
9. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in sequences of operation.
10. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in sequences of operation.
11. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.
12. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.
13. Energy Calculations.
 - a. The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
 - b. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.
14. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.
15. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

16. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as required by sequences of operation.

2.5 Controllers

- A. General. Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified by system performance. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of communicating actuators, communicating sensors, BACnet Smart Actuators and BACnet Smart Sensors.
- B. BACnet.
 1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
 2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
 3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
 4. Smart Actuators (SAs). An actuator which is controlled by a network connection rather than a binary or analog signal (0-10v, 4-20mA, relay, etc.). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.
 5. Smart Sensors (SSs). A sensor which provides information to the BAS via network connection rather than a binary or analog signal (0-10000 ohm, 4-20mA, dry contact, etc.). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135,

BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

6. BACnet Communication.
 - a. Building Controllers (BC). Each BC shall connect to a network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol using BACnet/IP or BACnet/SC.
 - b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
 - c. Each AAC shall connect to a network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol using BACnet/IP or BACnet/SC.
 - d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
 - f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.
- C. Security.
 1. Provide BACnet firewall capability, as defined in the BACnet standard.
- D. Building Controllers (BC)
 1. Communication
 - a. Network Connection. Controller shall support a single point ethernet connection.
 - b. Ethernet Port. Provide one (1) Gig-E port capable of full duplex communication up to 1000 Mbps
 - c. Service Port. Provide one (1) ethernet port for connection to a Portable Operator's Terminal.
 - d. Serial Port. Provide two (2) serial ports for communication to serial BACnet or serial Modbus networks.
 - e. Signal Management. BC shall have the ability to manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
 - f. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
 - g. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a

- piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.
2. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
 - a. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
 - b. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
 3. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.
 4. Real-time Clock. Controller shall have a real-time clock to keep track of time in the event of a power failure for up to three (3) days.
 5. Memory
 - a. Controller memory shall support operating system, database, and programming requirements.
 - b. Each BC shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.
- E. Advanced Application/Specific Controllers (AAC/ASC)
1. Communication
 - a. Network Connection. Controller shall support a single point ethernet connection or a daisy-chained ethernet connection using the Spanning Tree Protocol (STP).
 - b. Ethernet Port. Provide two (2) 10/100 Base T ethernet ports with ethernet switching capability.
 - c. Service Port. Provide one (1) USB port for connection to a Portable Operator's Terminal or a display.
 - d. Serial Port. Provide two (2) serial ports for communication to serial BACnet or serial Modbus networks.

- e. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.
2. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
 - a. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
 - b. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
3. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.
4. Real-time Clock. Controller shall have a real-time clock to keep track of time in the event of a power failure for up to three (3) days.
5. Memory
 - a. Controller memory shall support operating system, database, and programming requirements.
 - b. Each AAC shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.
- F. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
- G. Transformer. Power supply shall be fused or current limiting and shall be rated at a minimum of 125% of controller power consumption.

2.6 Input and Output Interface

- A. General. Hard-wire input and output points to BCs, AACs, or ASCs.

- B. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.
- C. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. Binary inputs shall sense dry contact closure without application of power external to the controller.
- D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.
- E. Analog Inputs. Analog inputs shall monitor low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
- F. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.
- G. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.
- H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.
- I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.7 Power Supplies and Line Filtering

- A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
 - 1. 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 150% current overload for at least three seconds without trip-out or failure.

- a. 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 MILSTD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA listed.
- B. Power Line Filtering.
1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
 - a. Dielectric strength of 1000 V minimum
 - b. Response time of 10 nanoseconds or less
 - c. Transverse mode noise attenuation of 65 dB or greater
 - d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.8 Local Control Panels

- A. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
- B. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
- C. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.9 Wiring and Raceways

- A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

PART 3: EXECUTION

- 3.0 Section Includes**
- 3.1 Examination**
- 3.2 Protection**
- 3.3 Coordination**
- 3.4 General Workmanship**
- 3.5 Field Quality Control**
- 3.6 Wiring**
- 3.7 Communication Wiring**
- 3.8 Fiber Optic Cable**
- 3.9 Installation of Sensors**
- 3.10 Flow Switch Installation**
- 3.11 Actuators**
- 3.12 Warning Labels**
- 3.13 Identification of Hardware and Wiring**
- 3.14 Controllers**
- 3.15 Programming**
- 3.16 Control System Checkout and Testing**
- 3.17 Control System Demonstration and Acceptance**
- 3.18 Cleaning**
- 3.19 Training**
- 3.20 Sequences of Operation**
- 3.21 Control Valve Installation**
- 3.22 Control Damper Installation**
- 3.23 Smoke Damper Installation**
- 3.24 Duct Smoke Detection**
- 3.25 Start-Up and Checkout Procedures**

3.1 Examination

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.
- C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.2 Protection

- A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 Coordination

- A. Site
 - 1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
 - 2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.
- B. Test and Balance.
 - 1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
 - 2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
 - 3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.

4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.
- C. Life Safety.
1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in sequences of operation.
 2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in sequences of operation.
 3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.
- D. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
1. All communication media and equipment shall be provided as specified in Section 23 09 23 Article 2.2 (Communication).
 2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in Section 23 09 93.
 3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
 4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.4 General Workmanship

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 Field Quality Control

- A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Section 23 09 23 Article 1.8 (Codes and Standards).
- B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.
- C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.6 Wiring

- A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.
- C. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.
- D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.
- E. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 3 m (10ft).
- F. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).
- G. Do not install wiring in raceway containing tubing.
- H. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.
- I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
- J. 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.
- K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.
- M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
- N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

- O. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- P. Include one pull string in each raceway 2.5 cm (1 in.) or larger.
- Q. Use color-coded conductors throughout with conductors of different colors.
- R. 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.
- S. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g. steam pipes or flues).
- T. 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.
- U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.
- V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.
- W. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- X. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- Y. 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 (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.7 Communication Wiring

- A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.
- B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling
- C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.
- D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.
- E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.
- F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lightning arrestor shall be installed according to manufacturer's instructions.
- G. All runs of communication wiring shall be unspliced length when that length is commercially available.

- H. All communication wiring shall be labeled to indicate origination and destination data.
- I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."
- J. BACnet IP, Arcnet, or MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
 - 1. IP
 - a. The network shall use Cat5e or greater cabling for connections.
 - b. Custom made patch cables must use either the T568A or T568 wiring standard and must use the same standard on both ends of the cable.
 - 2. Arcnet
 - a. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 nominal. Distributed capacitance between conductors shall be less than 12.5 pF per foot (41 pF per meter.)
 - b. The maximum length of an Arcnet segment is 610 meters (2000 ft) with AWG 22 cable.
 - c. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
 - d. An Arcnet network shall have no T connections
 - 3. MS/TP
 - a. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
 - b. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
 - c. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
 - d. An MS/TP EIA-485 network shall have no T connections.

3.8 Fiber Optic Cable

- A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
- B. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.9 Installation of Sensors

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

- B. Mount sensors rigidly and adequately for environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.
- D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.
- E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 3 m (10 ft) of sensing element for each 1 m² (1 ft²) of coil area.
- G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 3 m (10 ft) downstream.
- H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.
- I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.
- J. Differential Air Static Pressure.
 - 1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
 - 2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
 - 3. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
 - 6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.
- K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

- L. Install humidity sensors for duct mounted humidifiers at least 3 m (10 ft) downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 Flow Switch Installation

- A. Use correct paddle for pipe diameter.
- B. Adjust flow switch according to manufacturer's instructions.

3.11 Actuators

- A. General. Mount and link control damper actuators according to manufacturer's instructions.
 - 1. 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.
 - 2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
 - 3. Provide all mounting hardware and linkages for actuator installation.
- B. Electric/Electronic
 - 1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations.
 - 2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 Identification of Hardware and Wiring

- A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with control system address or termination number.
- B. All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.
- C. Permanently label or code each point of field terminal strips to show the instrument or item served.
- D. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.
- F. Identify room sensors related to terminal boxes or valves with nameplates.
- G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.13 Controllers

- A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in sequences of operation.

3.14 Programming

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging.
- B. Point Naming. Coordinate with owner for point naming conventions. Name points as shown on the equipment points list provided with each sequence of operation or as directed by owner. If character limitations or space restrictions make it advisable to shorten the name, abbreviations as coordinated with owner may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.
- C. Software Programming.
 - 1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
 - a. Text-based:
 - i. Must provide actions for all possible situations
 - ii. Must be modular and structured
 - iii. Must be commented
 - b. Graphic-based:
 - i. Must provide actions for all possible situations
 - ii. Must be documented
 - c. Parameter-based:
 - i. Must provide actions for all possible situations
 - ii. Must be documented.
- D. Operator Interface.
 - 1. Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point

information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List or sequence of operation.

2. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.15 Control System Checkout and Testing

- A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
 1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
 4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
 5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
 7. Alarms and Interlocks:
 - a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - b. 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.
 - c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.16 Control System Demonstration and Acceptance

A. Demonstration.

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:
 - a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
 - b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
 - c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or

change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

- d. Interface to the building fire alarm system.
 - e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

- 1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
- 2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.17 Cleaning

- A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- C. 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 to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.18 Training

- A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.
- B. Training shall enable students to accomplish the following objectives.
 - 1. Day-to-day Operators:

- a. Proficiently operate the system
 - b. Understand control system architecture and configuration
 - c. Understand DDC system components
 - d. Understand system operation, including DDC system control and optimizing routines (algorithms)
 - e. Operate the workstation and peripherals
 - f. Log on and off the system
 - g. Access graphics, point reports, and logs
 - h. Adjust and change system set points, time schedules, and holiday schedules
 - i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
 - j. Understand system drawings and Operation and Maintenance manual
 - k. Understand the job layout and location of control components
 - l. Access data from DDC controllers and ASCs
 - m. Operate portable operator's terminals
 2. Advanced Operators:
 - a. Make and change graphics on the workstation
 - b. Create, delete, and modify alarms, including annunciation and routing of these
 - c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
 - d. Create, delete, and modify reports
 - e. Add, remove, and modify system's physical points
 - f. Create, modify, and delete programming
 - g. Add panels when required
 - h. Add operator interface stations
 - i. Create, delete, and modify system displays, both graphical and others
 - j. Perform DDC system field checkout procedures
 - k. Perform DDC controller unit operation and maintenance procedures
 - l. Perform workstation and peripheral operation and maintenance procedures
 - m. Perform DDC system diagnostic procedures
 - n. Configure hardware including PC boards, switches, communication, and I/O points
 - o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
 - p. Adjust, calibrate, and replace system components
 3. System Managers/Administrators:
 - a. Maintain software and prepare backups
 - b. Interface with job-specific, third-party operator software
 - c. Add new users and understand password security procedures
 - C. Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on knowledge level required.
-

- D. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.
- E. The instructor(s) shall be factory-trained and experienced in presenting this material.
- F. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.19 Sequences of Operation

- A. See Section 23 Sequences of Operation

3.20 Control Valve Installation

- A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.
- C. Valves shall be installed in accordance with the manufacturer's recommendations.
- D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.
- E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.
- F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.21 Control Damper Installation

- A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
- B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.
- C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.
- D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
- E. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

- F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
- G. Provide a visible and accessible indication of damper position on the drive shaft end.
- H. Support ductwork in area of damper when required to prevent sagging due to damper weight.
- I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.22 Smoke Damper Installation

- A. The contractor shall coordinate all smoke and smoke/fire damper installation, wiring, and checkout to ensure that these dampers function properly and that they respond to the proper fire alarm system general, zone, and/or detector trips. The contractor shall immediately report any discrepancies to the engineer no less than two weeks prior to inspection by the code authority having jurisdiction.
- B. Provide complete submittal data to controls system subcontractor for coordination of duct smoke detector interface to HVAC systems.

3.23 Duct Smoke Detection

- A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."
- B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.24 Start-Up and Checkout Procedures

- A. Start up, check out, and test all hardware and software and verify communication between all components.
 - 1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - 2. Verify that all analog and binary input/output points read properly.
 - 3. Verify alarms and interlocks.
 - 4. Verify operation of the integrated system.

23 09 93 Sequence of Operations for HVAC Controls

PART 1: GENERAL

1.1 VAV AHU (typical of 1)

Run Conditions - Requested:

The unit shall run whenever:

- Any zone is occupied.
- OR a definable number of unoccupied zones need heating or cooling.

Emergency Shutdown:

The unit shall shut down and generate an alarm upon receiving an emergency shutdown signal.

Freeze Protection:

The unit shall shut down and generate an alarm upon receiving a freezestat status.

High Static Shutdown:

The unit shall shut down and generate an alarm upon receiving an high static shutdown signal.

Return Air Smoke Detection:

The unit shall shut down and generate an alarm upon receiving a return air smoke detector status.

Supply Air Smoke Detection:

The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

AHU Optimal Start:

The unit shall start prior to scheduled occupancy based on the time necessary for the zones to reach their occupied setpoints. The start time shall automatically adjust based on changes in outside air temperature and zone temperatures.

Supply Fan:

The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties.

To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Supply Air Duct Static Pressure Control:

The controller shall measure duct static pressure and shall modulate the supply fan VFD speed to maintain a duct static pressure setpoint of 1.5in H₂O (adj.). The supply fan VFD speed shall not drop below 30% (adj.).

Alarms shall be provided as follows:

- High Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) greater than setpoint.
- Low Supply Air Static Pressure: If the supply air static pressure is 25% (adj.) less than setpoint.
- Supply Fan VFD Fault.

Supply Air Temperature Setpoint - Optimized:

The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling and heating requirements

The supply air temperature setpoint shall be reset for cooling based on zone cooling requirements as follows:

- The initial supply air temperature setpoint shall be 55°F (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of 53°F (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of 72°F (adj.) .

If more zones need heating than cooling, then the supply air temperature setpoint shall be reset for heating as follows:

- The initial supply air temperature setpoint shall be 82°F (adj.).
- As heating demand increases, the setpoint shall incrementally reset up to a maximum of 85°F (adj.).
- As heating demand decreases, the setpoint shall incrementally reset down to a minimum of 72°F (adj.).

Cooling Coil Valve:

The controller shall measure the supply air temperature and modulate the cooling coil valve to maintain its cooling setpoint.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the supply fan status is on.
- AND the heating (if present) is not active.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is 5°F (adj.) greater than setpoint.

Heating Coil Valve:

The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its heating setpoint.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the supply fan status is on.
- AND the cooling (if present) is not active.

The heating coil valve shall open whenever:

- Supply air temperature drops from 40°F to 35°F (adj.).
- OR the freezestat (if present) is on.

Alarms shall be provided as follows:

- Low Supply Air Temp: If the supply air temperature is 5°F (adj.) less than setpoint.

Economizer:

The controller shall measure the mixed air temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F (adj.) less than the supply air temperature setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 40°F to 35°F (adj.).
- OR the freezestat (if present) is on.
- OR on loss of supply fan status.

The outside and exhaust air dampers shall close and the return air damper shall open when

the unit is off. If Optimal Start Up is available the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

Minimum Outside Air Ventilation - Fixed Percentage:

The outside air dampers shall maintain a minimum adjustable position during building occupied hours and be closed during unoccupied hours.

Mixed Air Temperature:

The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Temperature:

The controller shall monitor the return air temperature and use as required for setpoint control or economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Supply Air Temperature:

The controller shall monitor the supply air temperature.

Alarms shall be provided as follows:

- High Supply Air Temp: If the supply air temperature is greater than 120°F (adj.).
- Low Supply Air Temp: If the supply air temperature is less than 45°F (adj.).

Point Name	Hardware Points				Software Points							Show On Graphic
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm		
Mixed Air Temp	x									x		x
Return Air Temp	x									x		x
Supply Air Static Pressure	x									x	x	x
Supply Air Temp	x									x		x
Cooling Valve		x								x		x
Heating Valve		x								x		x
Mixed Air Dampers		x								x		x
Supply Fan VFD Speed		x								x		x
Freezestat			x							x	x	x
High Static Shutdown			x							x	x	x
Return Air Smoke Detector			x							x	x	x
Supply Air Smoke Detector			x							x	x	x
Supply Fan Status			x							x		x
Supply Fan VFD Fault			x								x	x
Supply Fan Start/Stop				x						x		x
Economizer Mixed Air Temp Set-point					x					x		x
Supply Air Static Pressure Setpoint					x					x		x
Supply Air Temp Setpoint					x					x		x
Emergency Shutdown						x				x	x	x
High Mixed Air Temp											x	
High Return Air Temp											x	
High Supply Air Static Pressure											x	
High Supply Air Temp											x	
High Supply Air Temp											x	
Low Mixed Air Temp											x	
Low Return Air Temp											x	
Low Supply Air Static Pressure											x	
Low Supply Air Temp											x	
Low Supply Air Temp											x	
Supply Fan Failure											x	
Supply Fan in Hand											x	
Supply Fan Runtime Exceeded											x	
Totals	4	4	6	1	3	1	0	0	0	18	20	19

Total Hardware (15)

Total Software (42)

AHU (typical of 16)

Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
 - A 75°F (adj.) cooling setpoint
 - A 70°F (adj.) heating setpoint.

- Unoccupied Mode (night setback): The unit shall maintain
 - A 85°F (adj.) cooling setpoint.
 - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Demand Limiting - Zone Setpoint Optimization:

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

Zone Setpoint Adjust:

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize

the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Freeze Protection:

The unit shall shut down and generate an alarm upon receiving a freezestat status.

Supply Air Smoke Detection:

The unit shall shut down and generate an alarm upon receiving a supply air smoke detector status.

Supply Fan:

The supply fan shall run anytime the unit is commanded to run, unless shutdown on safeties. To prevent short cycling, the supply fan shall have a user definable (adj.) minimum runtime.

Alarms shall be provided as follows:

- Supply Fan Failure: Commanded on, but the status is off.
- Supply Fan in Hand: Commanded off, but the status is on.
- Supply Fan Runtime Exceeded: Status runtime exceeds a user definable limit (adj.).

Cooling Coil Valve:

The controller shall measure the zone temperature and modulate the cooling coil valve to maintain its cooling setpoint.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the economizer (if present) is disabled or fully open.
- AND the zone temperature is above cooling setpoint.

- AND the supply fan status is on.
- AND the heating is not active.

The cooling coil valve shall open to 50% (adj.) whenever the freezestat (if present) is on.

Heating Coil Valve:

The controller shall measure the zone temperature and modulate the heating coil valve to maintain its heating setpoint.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the zone temperature is below heating setpoint.
- AND the supply fan status is on.
- AND the cooling is not active.

The heating coil valve shall open whenever the freezestat (if present) is on.

Economizer:

The controller shall measure the zone temperature and modulate the economizer dampers in sequence to maintain a setpoint 2°F less than the zone cooling setpoint. The outside air dampers shall maintain a minimum adjustable position of 20% (adj.) open whenever occupied.

The economizer shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the outside air temperature is less than the return air temperature.
- AND the supply fan status is on.

The economizer shall close whenever:

- Mixed air temperature drops from 45°F to 40°F (adj.).

- OR on loss of supply fan status.
- OR the freezestat (if present) is on.

The outside and exhaust air dampers shall close and the return air damper shall open when the unit is off. If Optimal Start Up is available, the mixed air damper shall operate as described in the occupied mode except that the outside air damper shall modulate to fully closed.

Minimum Outside Air Ventilation - Fixed Percentage:

The outside air dampers shall maintain a minimum position (adj.) during building occupied hours and be closed during unoccupied hours.

Mixed Air Temperature:

The controller shall monitor the mixed air temperature and use as required for economizer control (if present) or preheating control (if present).

Alarms shall be provided as follows:

- High Mixed Air Temp: If the mixed air temperature is greater than 90°F (adj.).
- Low Mixed Air Temp: If the mixed air temperature is less than 45°F (adj.).

Return Air Temperature:

The controller shall monitor the return air temperature and use as required for economizer control (if present).

Alarms shall be provided as follows:

- High Return Air Temp: If the return air temperature is greater than 90°F (adj.).
- Low Return Air Temp: If the return air temperature is less than 45°F (adj.).

Point Name	Hardware Points				Software Points						
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
Mixed Air Temp	x								x		x
Return Air Temp	x								x		x
Zone Setpoint Adjust	x										x

Point Name	Hardware Points				Software Points							Show On Graphic
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm		
Zone Temp	x									x		x
Cooling Valve		x								x		x
Heating Valve		x								x		x
Mixed Air Dampers		x								x		x
Freezestat			x							x	x	x
Supply Air Smoke Detector			x							x	x	x
Supply Fan Status			x							x		x
Zone Override			x							x		x
Supply Fan Start/Stop				x						x		x
Cooling Setpoint					x					x		x
Economizer Zone Temp Setpoint					x					x		x
Heating Setpoint					x					x		x
Schedule								x				
High Mixed Air Temp											x	
High Return Air Temp											x	
High Zone Temp											x	
Low Mixed Air Temp											x	
Low Return Air Temp											x	
Low Zone Temp											x	
Supply Fan Failure											x	
Supply Fan in Hand											x	
Supply Fan Runtime Exceeded											x	
Totals	4	3	4	1	3	0	0	1	14	11	15	

Total Hardware (12)

Total Software (29)

Outdoor Lighting (typical of 6)

Run Conditions:

The lighting output shall turn on and off based upon the local sunrise and sunset times. The transitions shall be configurable as follows:

Point Name	Hardware Points				Software Points						Show On Graphic
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	
Lighting Output				x					x		x
Totals	0	0	0	1	0	0	0	0	1	0	1

Total Hardware (1)
 Total Software (1)

Air Source Heat Pump (typical of 1)

Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
 - A 75°F (adj.) cooling setpoint
 - A 70°F (adj.) heating setpoint

- Unoccupied Mode (night setback): The unit shall maintain
 - A 85°F (adj.) cooling setpoint.
 - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Demand Limiting - Zone Setpoint Optimization:

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

Zone Setpoint Adjust:

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize

the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Freeze Protection:

The unit shall shut down and generate an alarm upon receiving a freezestat status.

Smoke Detection:

The unit shall shut down and generate an alarm upon receiving a smoke detector status.

Fan:

The fan shall run anytime the unit is commanded to run, unless shutdown on safeties.

Heating and Cooling - 1 Compressor Stage:

The controller shall measure the zone temperature and cycle the compressor to maintain its setpoint. To prevent short cycling, the stage shall have a user definable (adj.) minimum runtime. The compressor shall run subject to its own internal safeties and controls.

The heating shall be enabled whenever:

- Outside air temperature is less than 65°F (adj.).
- AND the fan is on.
- AND the reversing valve is in heat mode.

The cooling shall be enabled whenever:

- Outside air temperature is greater than 60°F (adj.).
- AND the fan is on.
- AND the reversing valve is in cool mode.

On mode change, the compressor shall be disabled and remain off until after the reversing valve has changed position..

Alarms shall be provided as follows:

- Compressor Runtime Exceeded: The compressor runtime exceeds a user definable limit (adj.).

Fan Status:

The controller shall monitor the fan status.

Alarms shall be provided as follows:

- Fan Failure: Commanded on, but the status is off.
- Fan in Hand: Commanded off, but the status is on.
- Fan Runtime Exceeded: Fan status runtime exceeds a user definable limit (adj.).

Point Name	Hardware Points				Software Points							Show On Graphic
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm		
Zone Setpoint Adjust	x											x
Zone Temp	x									x		x
Fan Status			x							x		x
Freezestat			x							x	x	x
Smoke Detector			x							x	x	x
Zone Override			x							x		x
Compressor Stage 1				x						x		x
Fan Start/Stop				x						x		x
Reversing Valve				x						x		x
Cooling Setpoint					x					x		x
Heating Setpoint					x					x		x
Schedule									x			
Compressor Runtime Exceeded											x	
Fan Failure											x	
Fan in Hand											x	
Fan Runtime Exceeded											x	

Point Name	Hardware Points				Software Points						Show On Graphic	
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm		
High Zone Temp											x	
Low Zone Temp											x	
Totals	2	0	4	3	2	0	0	1	10	8	11	

Total Hardware (9)

Total Software (21)

Variable Air Volume - Terminal Unit (typical of 6)

Run Conditions - Scheduled:

The unit shall run according to a user definable time schedule in the following modes:

- Occupied Mode: The unit shall maintain
 - A 75°F (adj.) cooling setpoint
 - A 70°F (adj.) heating setpoint.

- Unoccupied Mode (night setback): The unit shall maintain
 - A 85°F (adj.) cooling setpoint.
 - A 55°F (adj.) heating setpoint.

Alarms shall be provided as follows:

- High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
- Low Zone Temp: If the zone temperature is less than the heating setpoint by a user definable amount (adj.).

Demand Limiting - Zone Setpoint Optimization:

To lower power consumption, the zone setpoints shall automatically relax when the facility power consumption exceeds definable thresholds. The amount of relaxation shall be individually configurable for each zone. The zone setpoints shall automatically return to their previous settings when the facility power consumption drops below the thresholds.

Zone Setpoint Adjust:

The occupant shall be able to adjust the zone temperature heating and cooling setpoints at the zone sensor.

Zone Optimal Start:

The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize

the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

Zone Unoccupied Override:

A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. At the expiration of this time, control of the unit shall automatically return to the schedule.

Reversing Variable Volume Terminal Unit - Flow Control:

The unit shall maintain zone setpoints by controlling the airflow through one of the following:

Occupied:

- When zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When the zone temperature is between the cooling setpoint and the heating setpoint, the zone damper shall maintain the minimum required zone ventilation (adj.).
- When zone temperature is less than its heating setpoint, the controller shall enable heating to maintain the zone temperature at its heating setpoint. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the minimum occupied airflow (adj.) and the maximum heating airflow (adj.) until the zone is satisfied.

Unoccupied:

- When the zone is unoccupied the zone damper shall control to its minimum unoccupied airflow (adj.).
- When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate between the minimum unoccupied airflow (adj.) and the maximum cooling airflow (adj.) until the zone is satisfied.
- When zone temperature is less than its unoccupied heating setpoint, the controller shall enable heating to maintain the zone temperature at the setpoint. Additionally, if warm air is available from the AHU, the zone damper shall modulate between the

minimum unoccupied airflow (adj.) and the auxiliary heating airflow (adj.) until the zone is satisfied.

Point Name	Hardware Points				Software Points						Show On Graphic
	AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	
Airflow	x								x		x
Zone Setpoint Adjust	x										x
Zone Temp	x								x		x
Zone Damper		x							x		x
Zone Override			x						x		x
Airflow Setpoint					x				x		x
Cooling Setpoint					x				x		x
Heating Setpoint					x				x		x
Heating Mode						x			x		
Schedule								x			
High Zone Temp										x	
Low Zone Temp										x	
Totals	3	1	1	0	3	1	0	1	8	2	8

Total Hardware (5)

Total Software (15)

Point Summary

Point Name	Qty	Hardware Points				Software Points						
		AI	AO	BI	BO	AV	BV	Loop	Sched	Trend	Alarm	Show On Graphic
VAV AHU (Typical of 1)	Each	4	4	6	1	3	1	0	0	18	20	19
	Total (x1)	4	4	6	1	3	1	0	0	18	20	19
AHU (Typical of 16)	Each	4	3	4	1	3	0	0	1	14	11	15
	Total (x16)	64	48	64	16	48	0	0	16	224	176	240
Outdoor Lighting (Typical of 6)	Each	0	0	0	1	0	0	0	0	1	0	1
	Total (x6)	0	0	0	6	0	0	0	0	6	0	6
Air Source Heat Pump (Typical of 1)	Each	2	0	4	3	2	0	0	1	10	8	11
	Total (x1)	2	0	4	3	2	0	0	1	10	8	11
Variable Air Volume - Terminal Unit (Typical of 6)	Each	3	1	1	0	3	1	0	1	8	2	8
	Total (x6)	18	6	6	0	18	6	0	6	48	12	48

Project Totals	88	58	80	26	71	7	0	23	306	216	324
-----------------------	-----------	-----------	-----------	-----------	-----------	----------	----------	-----------	------------	------------	------------

Total Hardware (252)

Total Software (623)

- 1.0 Section Includes**
- 1.1 VAV AHU**
- 1.2 AHU**
- 1.3 Outdoor Lighting**
- 1.4 Air Source Heat Pump**
- 1.5 Variable Air Volume - Terminal Unit**
- 1.6 Point Summary**

APPENDIX A: Definitions

Terms used within the Specification Text:

- **Adjustable (adj.):**

Adjustable by the end user, through the supplied user interface.

- **Advanced Application Controller (AAC):**

A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

- **Alarm:**

The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

- **Analog Value:**

An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.

- **Application Specific Controller (ASC):**

A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

- **BACnet Interoperability Building Blocks (BIBB):**

A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.

- **BACnet/BACnet Standard:**

BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.

- **Binary Value:**

An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.

- **Building Controller (BC):**

A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

- **Control Systems Server:**

A computer(s) that maintain(s) the systems configuration and programming database.

- **Controller:**

Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.

- **Direct Digital Control (DDC):**

Microprocessor-based control including Analog/Digital conversion and program logic.

- **Furnished or Provided:**

The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

- **Gateway:**

Bi-directional protocol translator connecting control systems that use different communication protocols.

- **Install or Installed:**

The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

- **Integrate:**

The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

- **Interface:**

The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

- **Local Area Network:**

Computer or control system communications network limited to local building or campus.

- **Loop or control loop:**

Most commonly a PID control loop. Typically a control loop will include a setpoint, an input which is compared to the setpoint, and an output which controls some action based upon the difference between the input and the setpoint. A PID control loop will also include gains for the proportional, integral, and derivative response as well as an interval which controls how frequently the control loop updates its output. These gains may be adjustable by the end user for control loop "tuning," but in self-tuning control loops or loops which have been optimized for a specific application the gains may not be adjustable.

- **Master-Slave/Token Passing (MS/TP):**

Data link protocol as defined by the BACnet standard.

- **Point-to-Point:**

Serial communication as defined in the BACnet standard.

- **Primary Controlling LAN:**

High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.

- **Protocol Implementation Conformance Statement (PICS):**

A written document that identifies the particular options specified by BACnet that are implemented in a device.

- **Router:**

A device that connects two or more networks at the network layer.

- **Schedule:**

The control algorithm for this equipment shall include a user editable schedule.

- **Trend:**

The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)

- **Web services:**

Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

- **Wiring:**

Raceway, fittings, wire, boxes and related items.

APPENDIX B: Abbreviations

The following abbreviations are utilized within this section and the sequences of operations. Refer to mechanical drawings for additional abbreviations.

AC – Air Conditioning
ACU – Air Conditioning Unit
AHU – Air Handling Unit
AI – Analog Input
AO – Analog Output
ATC – Automatic Temperature Control
AUTO – Automatic
AUX – Auxiliary
AV – Analog Value
BAS – Building Automation System
BI – Binary Input
BO – Binary Output
BV – Binary Value
C – Common
CFM – Cubic Feet per Minute
CHW – Chilled Water
CHWP – Chilled Water Pump
CHWR – Chilled Water Return
CHWS – Chilled Water Supply
COND – Condenser
CV – Constant Volume
CW – Condenser Water
CWP – Condenser Water Pump
CWR – Condenser Water Return
CWS – Condenser Water Supply
DA – Discharge Air
DDC – Direct Digital Control
DI – Digital Input
DO – Digital Output
EA – Exhaust Air
EF – Exhaust Fan
EVAP – Evaporators
FAS – Fire Alarm System
FCU – Fan Coil Unit
HOA – Hand / Off / Auto
HP – Heat Pump
HRU – Heat Recovery Unit

HVAC – Heating, Ventilating, and Air Conditioning
HW – Hot Water
HWP – Hot Water Pump
HWR – Hot Water Return
HWS – Hot Water Supply
HX – Heat Exchanger
IU – Induction Unit
LAN – Local Area Network
MER – Mechanical Equipment Room
NC – Normally Closed
NO – Normally Open
OA – Outdoor Air
PID – Proportional Integral Derivative
POT – Portable Operators Terminal
RA – Return Air
RF – Return Fan
RH – Relative Humidity
RTU – Roof-top Unit
SA – Supply Air
SF – Supply Fan
SP – Static Pressure
TEMP – Temperature
UH – Unit Heater
UV – Unit Ventilator
VAV – Variable Air Volume
VFD – Variable Frequency Drive
VRF – Variable Refrigerant Flow
VRV – Variable Refrigerant Volume
WSHP – Water Source Heat Pump