



REQUEST FOR QUOTE # 16778

RFQ # 16778

Quotation Due By: 03/21/2014
 Bid Due Time: 12:00:00 PM

REPLY TO:

VENDOR INFO:

VENDOR #: 99999.00

Gai Hunter
 PURCHASING DEPARTMENT
 Grand River Dam Authority
 226 W DWAIN WILLIS AVE
 PO BOX 409
 VINITA OK 74301
 PHONE: 405-297-9963 ext 4653
 FAX: 405-840-1390
 EMAIL: ghunter@grda.com

NAME: _____
 CONTACT: _____
 ADDRESS 1: _____
 ADDRESS 2: _____
 CITY: _____ STATE: _____ ZIP: _____
 EMAIL: _____
 PHONE: _____ FAX: _____

NOTE: 1.The bid opening date for this RFQ is 03/21/14 at Noon CT. Bidder is to submit a response to Gai Hunter via email at ghunter@grda.com or fax at 405-840-1390 no later the bid opening date and time. Questions regarding this RFQ must be submitted in writing to Gai Hunter at ghunter@grda.com no later than 03/19/14 at 5:00PM CT.

2.A completed non-collusion certificate is required and must be submitted with your bid.

3.This form must be signed by an authorized representative of your company in the space provided in the lower right hand corner of this form.

4.The award to the successful bidder will be based on the lowest and best bid received that meets the specifications listed below and the requirements herein. Preference may be given to E-pay vendors if analysis estimates that such appears to result in a lower cost to GRDA.

***** Read the General Bidding Instructions attached to this RFQ for further instructions.*****

GRDA Visa Payment

GRDA provides a Visa payment program which invoices payment by a secure Visa account number assigned to the supplier after award of contract. Notification of payments and required invoice information are issued to your designated Accounts Receivable contact by e-mail remittance payment.

Preference may be shown during the evaluation process to bidders that agree to accept the Visa payment of invoices. To learn more about the benefits of the Visa payment program, and to obtain answers to FAQ, click or copy and paste the following URL into your browser: www.bankofamerica.com/epayablesvendors.

Will accept payment by Visa: Yes No (check one)

Visa acceptance signature: _____

Designated Accounts Receivable Contact for Visa remittance advices:

Name: _____

Phone: _____

Email: _____

LINE ITEM	DESCRIPTION	NUMBER OF UNITS	UNIT OF MEASURE	UNIT PRICE	LINE COST	LEAD TIME
1	HVAC Control System and Installation Service: **** * SEE ATTACHMENTS FOR MORE DETAILS*****	1.0	\$	_____	_____	_____

Bidder is to also indicate below:

LINE ITEM	DESCRIPTION	NUMBER OF UNITS	UNIT OF MEASURE	UNIT PRICE	LINE COST	LEAD TIME
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Proposed HVAC Control System Manufacturer:

Proposed Product Line and Model:

This RFQ is to purchase an approved HVAC control system and system installation service. A firm, fixed price shall include HVAC control system, installation service and all related expenses including delivery and travel.

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.

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.

Approved Control system Manufacturers - the following are approved control system manufacturers, and product lines:

Mfg: Automated Logic Corporation
Product Line: WebCTRL

Mfg: Invensys
Product Line: Tridium

Mfg: Honeywell
Product Line: Honeywell

Mfg: Staefa
Product Line: Talon

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.

1. The Contractor shall use only operator workstation



REQUEST FOR QUOTE # 16778

LINE ITEM	DESCRIPTION	NUMBER OF UNITS	UNIT OF MEASURE	UNIT PRICE	LINE COST	LEAD TIME
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software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

2. Other products specified herein (such as sensors, dampers, and actuators) need not be manufactured by the above manufacturers.

Quality Assurance-Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.
2. Installer shall have successfully completed Control System Manufacturers control system training. Upon request, Installer shall present record of completed training including course outlines.

Proof must be provided upon request.

*****See 2 attachments for details*****

Ship To Address: GRDA Engineering and Technology Center
 9933 E 16th Street
 Tulsa OK 74128

NOTE: All prices must be quoted FOB: Destination. All freight charges to delivery point must be included in the unit price quoted for each line item. All packaging, handling, delivery and any other surcharges must also be included in the price quoted for each line item.

PAYMENT TERMS: _____

QUOTE EXPIRATION DATE: _____

QUOTATION NUMBER: _____

QUOTED BY (please print): _____

SHIP TO: Grand River Dam Authority
 GRDA Engineering and Technology Center
 9933 E 16th Street
 TULSA OK 74128

COMPANY NAME: _____

SIGNATURE: _____

DATE OF QUOTE: _____

THIS IS NOT AN ORDER. We would be pleased to receive your quotation for furnishing the above. This form must be completed **in full** (including signature) and returned by the due date above. You may attach additional pages if necessary. If attached, the Non-Collusion form must be completed and returned with your quotation. NO PARTIAL SHIPMENTS OR PARTIAL PAYMENTS WILL BE ALLOWED WITHOUT PRIOR APPROVAL.

All articles purchased hereunder shall be in accordance with the Bidding Procedures and General Terms & Conditions contained on the attached sheets.



GRAND RIVER DAM AUTHORITY

NON-COLLUSION CERTIFICATE

RFQ / RFP # _____

A Non-Collusion Certificate shall be included with any competitive bid or contract submitted to the Authority for goods or services exceeding \$5,000.00 (but not exceeding \$50,000.00), with the exception of those for the purpose of repairs and improvements to GRDA facilities.

A. For purposes of competitive bid or contract, I certify:

1. I am the duly authorized agent of _____, (Company Name), the bidder submitting the competitive bid which is attached to this statement, for the purpose of certifying the facts pertaining to the existence of collusion among bidders and between bidders and state officials or employees, as well as facts pertaining to the giving or offering of things of value to government personnel in return for special consideration in the letting of any contract pursuant to said bid;
2. I am fully aware of the facts and circumstances surrounding the making of the bid to which this statement is attached and have been personally and directly involved in the proceedings leading to the submission of such bid; and
3. Neither the bidder, nor contractor, nor anyone subject to the bidder's or contractor's direction or control, has been a party:
 - a. to any collusion among bidders in restraint of freedom of competition by agreement to bid at a fixed price or to refrain from bidding,
 - b. to any collusion with any state official or employee as to quantity, quality or price in the prospective contract, or as to any other terms of such prospective contract, nor
 - c. in any discussions between bidders and any state official concerning exchange of money or other thing of value for special consideration in the letting of a contract, nor, whether competitively bid or not, has paid, given or donated or agreed to pay, give or donate to any officer or employee of the State of Oklahoma any money or other thing of value, either directly or indirectly, in procuring this contract herein.

B. The contractor further certifies that no person who has been involved in any manner in the development of said contract while employed by the State of Oklahoma shall be employed to fulfill any of the services provided for under said contract.

C. If any contract pursuant to this bid is for professional services as defined in 74 O.S. § 85.2.25, and if the final product is a written proposal, report or study, the contractor further certifies that (s)he has not previously provided the state agency or any other state agency with a final product that is a substantial duplication of the final product of the proposed contract.

Authorized Signature

Certified this Date

Printed Name

Title

Telephone Number

Fax Number

E-Mail

GENERAL BIDDING INSTRUCTIONS FOR STANDARD & EMERGENCY BIDS

1. Bids shall be submitted to the designated purchasing agent at the Grand River Dam Authority (hereinafter referred to as “GRDA” or “the Authority”) at the address on the attached RFQ or RFP form on or before the date (and time, if applicable) indicated. Bids shall be in conformity with these and any additional instructions to bidders and shall be submitted on GRDA’s form. **The RFQ (Request for Quote) or RFP (Request for Proposal) form must be completed in full and signed by the bidder.** If your bid response necessitates additional space, you may attach additional pages; however, the RFQ or RFP form must be completed, signed and reference the additional pages. All bid responses shall be typewritten or handwritten in ink, and any corrections to bids shall be initialed in ink. Quotations or proposals submitted in pencil shall not be accepted.
2. Quotations or proposals may be submitted to GRDA via postal mail, delivery service, fax or e-mail, provided all required signatures can be transmitted successfully.
3. **Non-Collusion Certificate:** RFQs or RFPs anticipated to exceed a total amount of \$5,000 shall be accompanied by a Non-Collusion Certificate. This certificate shall be completed by the bidder and include a signature in ink of an authorized company representative (preferably the bidder) with full knowledge and acceptance of the bid proposal. In the case of bids submitted via fax or e-mail, the Non-Collusion Certificate may be submitted with the bid. Purchase orders in excess of \$5,000 will not be released to the successful bidder without receipt of a properly signed certificate for the bid.
4. In the event the unit price and line total extension do not agree, the unit price shall be considered the quoted price accepted for evaluation.
5. **Freight Terms:** All prices shall be quoted FOB: Destination/Freight Allowed. All packaging, handling, shipping and delivery charges shall be included in the unit price quoted for each line item. No exceptions shall be granted unless approved by the guidelines of the GRDA Chief Financial Officer or designee.
6. **Other Surcharges:** Any additional surcharges (such as HazMat charges, fuel surcharges, set-up fees, etc.) shall be included in the unit price quoted for each line item. All additional charges are considered a part of the cost of the goods, and bids shall be evaluated to include these additional charges.
7. **Tax-Exempt Status:** GRDA is an agency of the state of Oklahoma and is specifically exempt from the payment of sales tax by Oklahoma state statute, Title 68 O.S.A. § 1356 (10). An excerpt from the statute shall be furnished upon request.
8. **Questions arising during the bidding process should be submitted in writing to the GRDA purchasing agent named on the RFQ or RFP.** The GRDA purchasing agent shall coordinate a reply from the end user to ensure that all potential bidders are provided the same information. Under no circumstances shall a bidder discuss pricing with any GRDA employee prior to the bid opening.
9. All bids submitted shall be subject to GRDA’s Purchasing Policy and Procedures, General Terms and Conditions, the bidding instructions and specifications, the Oklahoma Open Records Act, other statutory regulations as applicable, and any other terms and conditions listed or attached herein – all of which are made part of this Request for Quote or Request for Proposal.
10. GRDA reserves the right to reject any and all bids, and to contract as the best interests of the Authority may require. GRDA reserves the right to reject any bids that do not comply with the requirements and specifications of the Request for Quote or Request for Proposal. All bid responses become the property of GRDA and are subject to the Oklahoma Open Records Act. GRDA shall endeavor to protect technical information designated by the bidder as proprietary information; however, only technical information (i.e., “trade secrets”) may be considered proprietary – pricing and other non-technical aspects of the quote shall be considered non-proprietary.
11. **“Sole Brand” or “No Sub” Items:** Items with a “Sole Brand” or “No Sub” designation in the description shall be furnished as the specified manufacturer and model/part number. No exception may be taken to the specification, and no alternate shall be accepted. In those cases where a manufacturer has discontinued the specified model/part number, the bidder shall indicate so on the RFQ. If a replacement item is available, the new model/part number shall be indicated on the RFQ form and the price quoted. It shall also be noted whether the replacement item is a direct replacement for the obsolete part number originally requested. If not, or if the specifications differ in any way, the bidder shall explain in detail, and corresponding drawings or descriptive literature shall be included with the quote.

12. **Approved Equivalents:** Unless an item is designated as a “Sole Brand” or “No Sub” item, any manufacturer’s name, brand name, information and/or catalog number listed in a specification is for informational or cross-reference purposes and is not intended to limit competition. Bidders may offer any brand/manufacturer for which they are an authorized representative, provided it meets or exceeds the specification of the listed item. However, if quoting an equivalent product, bidders shall indicate on the RFQ form the manufacturer’s name and part number. Bidder shall also submit any drawings, descriptive literature and specifications for evaluation purposes. Reference to literature submitted with a previous bid shall not satisfy this provision. The bidder shall also provide written confirmation that the proposed equivalent will meet the requested specifications and is not considered an exception. Bids which do not comply with these requirements may be rejected. GRDA warehouses are not permitted to accept any item with a part number differing from that quoted by the bidder. Bids lacking any written indication of intent to furnish an alternate brand, model or part number shall be considered to be in complete compliance with the specifications as listed on the RFQ.
13. **Insurance Certificates:** Any service to be performed that requires the vendor’s employee, vehicle or equipment to be on any GRDA property must be covered by minimum insurance requirements. The workscope to be performed for the Authority shall be evaluated and the minimum insurance requirements shall be provided to prospective bidders with the RFQ or RFP. Evidence of insurance coverage shall be furnished in the form of a Certificate of Insurance, and shall be submitted with the bid response. Bidders shall disclose any subcontractors to be used, and the Authority shall consider the supplier as the single point of contact. The supplier shall assume responsibility for the performance of the subcontractor. Policies shall remain current for the duration of the requested service period, and GRDA shall be notified of any cancellation or revision to policies. Purchase Orders shall not be released to the successful bidder without a current Certificate of Insurance naming GRDA as certificate holder on file. A Memorandum of Insurance shall not be acceptable for this requirement.
14. **MSDS:** Material Safety Data Sheets shall be furnished to GRDA’s Safety Department at the address noted on the PO prior to delivery of items.
15. **Purchase Orders** shall be awarded to the “lowest and best” or “best value” bidder. Line items may be split into multiple orders, taking low items from each respective bidder, or orders may be awarded on an “all or none” basis, whichever is in the best interests of the Authority. Award decisions are further subject to consideration of any additional terms and conditions contained in the bid proposal. Vendor protests must be submitted in writing to the Central Purchasing Unit of GRDA within thirty-six (36) hours of award of Contract or Purchase Order.
16. Successful vendor shall deliver the merchandise or perform the service as quoted. Substitutions or changes without prior approval of the GRDA purchasing agent shall be rejected and returned at the vendor’s expense.
17. **Bidder Responsibilities:** Bidders are to transact all phases of the purchasing function directly with the GRDA purchasing agent. Bidders are to conduct all written and verbal communication with the Authority through the GRDA purchasing agent. Bidders are to conduct negotiations ethically, without attempts to influence through offers of valuable personal gifts or entertainment. Bidders are to make available as requested any technical information which might be of benefit in the bid evaluation.
18. **Supplier List:** The Finance Department maintains a current listing of suppliers with a cross-reference as to products and services offered. Suppliers may have their names added to the list by submitting a completed Vendor Registration/Payee Application, and shall notify the Authority of any update information. If a supplier fails to respond to bid requests after four appropriate solicitations, that supplier may be removed from the active list. Suppliers who do not meet quoted shipping dates or lead times, supply products or services of poor quality, substitute items of unequal quality, continually over-ship or under-ship items, or do not invoice properly may be placed under suspension or disqualified from the active supplier list. Suppliers may voluntarily request to be removed from the supplier database.
19. **Service Contracts:** By submitting a bid for services, the bidder certifies that they, and any proposed subcontractors, are in compliance with 25 O.S. §1313 and participate in the Status Verification System. The Status Verification System is defined in 25 O.S. §1312 and includes, but is not limited to, the free Employment Verification Program (E-Verify) available at www.dhs.gov/E-Verify. This shall remain in effect through the entire term, including all renewal periods, of the contract. The State may request verification of compliance for any contractor or subcontractor. Should the State suspect or find the contractor or any of its subcontractors are not in compliance, the State may pursue any and all remedies allowed by law, including, but not limited to: suspension of work, termination of the contract for default, and suspension or debarment of the contractor. All costs necessary to verify compliance are the responsibility of the contractor.

GENERAL TERMS AND CONDITIONS



Any contract or order issued by the Grand River Dam Authority (hereinafter referred to as GRDA) is expressly conditioned upon Seller's assent to these terms and conditions, unless otherwise agreed in writing. Any order issued or filled by Seller shall be deemed to constitute Seller's assent to these terms and conditions. Any additional or different terms submitted by the Seller are hereby expressly objected to by GRDA unless expressly agreed to in writing by GRDA.

1. Mail or deliver all invoices or correspondence pertaining to the payment of this Purchase Order to: Accounts Payable Department, Grand River Dam Authority, P.O. Box 409, 226 West Dwain Willis Avenue, Vinita, Oklahoma 74301. Seller shall submit invoices, with one copy detailing each item with unit prices, with the top copy being distinguishable as an original, accompanied by one copy of complete shipping papers. If shipment is not made by routing instructions as specified on the face of this Purchase Order, GRDA reserves the right to deduct any excess transportation charges resulting therefrom. Copy of original freight bill must be supplied for payment. Time, in connection with any discount offered, will be computed from date of delivery of items, or from date the correct invoice is received in Vinita, Oklahoma, whichever period of time is the later date. No Oklahoma State Sales or Use Tax shall be included in payment of this Purchase Order.
2. All articles, materials, equipment and supplies (hereinafter referred to as "items") covered by this Purchase Order, unless otherwise specified, are purchased subject to inspection before and during manufacture and upon arrival at destination. GRDA reserves the right to return for full credit and/or refund, at Seller's sole risks and expense, including all transportation and storage charges, all items found defective or furnished contrary to instructions and/or specifications contained herein.
3. In case of default by Seller, GRDA may procure the items or services from other sources and hold Seller responsible for any excess cost occasioned thereby; provided, that if necessity requires the use of items not conforming to specifications, they may be accepted, and payment made at a proper reduction in price. Notwithstanding anything herein to the contrary, GRDA reserves the right to terminate this Purchase Order for its convenience. In the event of such termination, GRDA shall pay and Seller shall accept the reasonable value of all work performed and items delivered by Seller up through the effective date of such termination.
4. Seller warrants that all items covered by this Purchase Order will conform to the specifications, drawings, samples or other description furnished by GRDA, or any revisions thereof, and any items purchased pursuant to this Purchase Order shall be subject to all warranties expressed or implied by law, and will be merchantable of good material and fit and sufficient for the purpose intended, and shall satisfy any performance guarantee requirements as specified herein by GRDA. In the event the items and/or services purchased hereunder do not meet the warranty specified hereinabove, Seller shall promptly repair or replace any defective item at its expense, or re-perform any necessary services, and shall hold GRDA harmless from any and all costs and expenses incurred due to said defective item or performance of services, including the cost for removing any part or product to be repaired or replaced, as well as transportation and installation charges in connection with the repair, replacement or servicing of any parts or equipment. Seller further agrees that the manufacturer's warranties and guaranties of the items purchased hereunder extended to Seller shall extend to GRDA.
5. Seller shall indemnify and hold GRDA harmless from and against any and all loss, costs or expenses arising out of any liens or claims in any way related to the items or services furnished hereunder. Seller shall likewise indemnify and hold GRDA harmless from any patent, trademark or copyright infringement, except items supplied in accordance with design originating with GRDA. Seller shall be an independent contractor. Seller shall protect, defend, indemnify and hold GRDA harmless from any damage or injury to any persons, including Seller's employees or property, and from any claim, demand, action, cost or expense arising out of the activities hereunder as a result of Seller's negligent or intentional wrongful acts. In no event shall Seller's liability be limited under this Purchase Order for the negligent or intentional wrongful acts of the Seller.
6. Seller shall, before any items are shipped and/or any services are commenced, provide GRDA with certificates evidencing that the following minimum insurance will remain in force until Seller's obligations are completed: (a) Workmen's Compensation Insurance, including Employer's Liability Insurance, in accordance with the laws of the state in which Seller may be required to pay compensation; and (b) Public Liability Insurance with an individual limit of not less than \$100,000 and a total for any one accident of not less than \$300,000, unless otherwise specified herein.
7. This Purchase Order (including Seller's right to receive payments hereunder) shall not be assigned or subcontracted in whole or in part without GRDA's prior written consent. No assignment hereof shall relieve this assignor of its obligations hereunder.
8. Service Contracts: By submitting a bid for services, the Bidder certifies that they, and any proposed Subcontractors, are in compliance with 25 O.S. §1313 and participate in the Status Verification System. The Supplier/Contractor/Consultant/Construction Manager/etc. certifies that it and all proposed Subcontractors, whether known or unknown at the time a contract is executed or awarded, are in compliance with 25 O.S. §1313 and participate in the Status Verification System. The Status Verification System is defined in 25 O.S. §1312 and includes, but is not limited to, the free Employment Verification Program (E-Verify) available at www.dhs.gov/E-Verify. This shall remain in effect through the entire term, including all renewal periods, of the Contract. The State may request verification of compliance for any Contractor or Subcontractor. Should the State suspect or find the Contractor or any of its Subcontractors are not in compliance, the State may pursue any and all remedies allowed by law, including, but not limited to: suspension of work, termination of the Contract for default, and suspension or debarment of the Contractor. All costs necessary to verify compliance are the responsibility of the Contractor.
9. All Items shipped pursuant to this Purchase Order will conform with all municipal, state and federal laws, ordinances and regulations, and Seller will defend and save harmless GRDA from loss, costs or damage by reason of any actual or alleged violation thereof.
10. GRDA hereby notifies Seller that Seller must comply, and by acceptance of this Purchase Order, Seller represents that it has complied with, and will continue to comply with, all applicable federal, state and local laws, regulations or orders.
11. This Purchase Order shall be construed as being performed by both parties in Craig County, Oklahoma, and shall be governed in accordance with the laws of the State of Oklahoma.

Grand River Dam Authority is an agency of the State of Oklahoma.

Administrative Headquarters • 226 West Dwain Willis Avenue • Vinita, Oklahoma 74301 • Phone: 918-256-5545 • Fax: 918-256-1051

INSURANCE REQUIREMENT "A"



To be submitted with a bid response

MINIMUM INSURANCE REQUIREMENTS

COMPREHENSIVE GENERAL LIABILITY

Bodily Injury	\$100,000.00 per person \$300,000.00 per occurrence
Property Damage	\$100,000.00 per occurrence

COMPREHENSIVE AUTOMOBILE LIABILITY

Should include owned, non-owned and hired autos, trucks and trailers

Same limits as General Liability

WORKERS' COMPENSATION

As required by the laws of the State of Oklahoma and Employers' Liability limit of \$100,000.00

These limits could be satisfied by either primary coverage or a combination of primary and umbrella coverage.

A Certificate of Insurance must accompany bids on any work to be performed for GRDA.

The Certificate of Insurance must show the name and address of the insured, the GRDA Purchase Order number and/or description of the job to be performed for GRDA, limits of coverage, policy number, effective and expiration dates, etc. The cancellation clause must provide that the Authority is to receive ten (10) days written notice prior to cancellation or to the making of any material change. The successful bidder must inform the insurance agent to submit a revised Certificate of Insurance at renewal of the coverage if the GRDA work will extend until that time.





Invoice Affidavit Certification for Payment

(For Projects under the Statutory Amount or Minor Project without a Design Consultant)

Progress Payment

Date of Progress Invoice: _____

Final Payment

Date of Final Invoice: _____

STATE OF OKLAHOMA)

Project Name: _____

) ss

COUNTY OF _____)

Project No.: _____

CONTRACTOR OR SUPPLIER – COMPLETE THIS SECTION (Choose Appropriate Option)

Option 1: Contract Award is Less than \$50,000 and Affidavit Provided in lieu of Statutory Bonds

Affidavit: The undersigned Contractor or Supplier hereby affirms under oath that to the best of my knowledge, information and belief, the Work or Materials covered by this Invoice for Payment has been completed or materials delivered in accordance with the Contract Documents, that all amounts have been paid by the Contractor or Supplier for Work or Materials for which previous Invoices for Payment, if any, were issued and payments received from GRDA, and that current payment shown herein is now due. In accordance with 61O.S., § 1.(C), the Contractor acknowledges that the execution of this affidavit with knowledge that any of the contents of the affidavit are false, upon conviction, shall constitute perjury, punishable as provided for by law.

Option 2: Contract Award is Greater than \$50,000 and Statutory Bonds have been provided

Certification: The undersigned Contractor or Supplier hereby certifies that to the best of my knowledge, information and belief, the Work or Materials covered by this Invoice for Payment has been completed or materials delivered in accordance with the Contract Documents, that all amounts have been paid by the Contractor or Supplier for Work or Materials for which previous Invoices for Payment, if any, were issued and payments received from GRDA, and that current payment shown herein is now due.

Firm Name

Printed Name and Title

Signature

(NOTARIZE ONLY IF OPTION 1 ABOVE IS CHECKED)

Subscribed and sworn to before me this _____ day of _____, _____

by _____

Notary Public

My Commission Expires _____

CERTIFICATION OF SUPERVISORY OFFICIAL (GRDA's Representative)

In accordance with the Contract Documents, based on on-site observations and the data comprising the Invoice for Payment, the Supervisory Official certifies to GRDA that to the best of the Supervisory Official's knowledge, information and belief the Work has progressed as indicated, the quality of the Work is in accordance with the Contract Documents, and the Contractor is entitled to payment of the Amount Certified. Attach Copy of Approved Invoice.

Signature

Title

Printed Name

Date

SECTION 230923 – CONTROL FOR HVAC

PART 1: GENERAL

1.1 Related Sections

- A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.
- B. The following sections constitute related work:
 - 1. Section 23 05 00 – Heating, Ventilating and Air-Conditioning

1.2 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. 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.

1.3 Approved Control system Manufacturers

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

Supplier	Manufacturer	Product Line
ES2	Automated Logic Corporation	WebCTRL
ABS	Invensys	Tridium
Panco	Honeywell	Honeywell
Integrated Controls Systems	Staefa	Talon

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.

- 1. 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.
- 2. Other products specified herein (such as sensors, dampers, and actuators) need not be manufactured by the above manufacturers.

1.4 Quality Assurance

- A. Installer and Manufacturer Qualifications
 - 1. Installer shall have an established working relationship with Control System Manufacturer.
 - 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.

1.5 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. Chapter 28 Mechanical
 - 3. International Mechanical Code (IMC)

1.6 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 operator workstation (server and browser for web-based systems).
 - 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 workstation within 45 sec.
 - 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
 - 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 workstation on the network shall receive alarms within 5 sec of other workstations.
 - 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	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±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	±1.5°C (±3°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

1.7 Submittals

- A. Product Data and Shop Drawings: Meet requirements of Section 01 30 00 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide shop drawings or other submittals 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 drawings as AutoCAD 2006 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and three 11” x 17” prints of each drawing. 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. Relays and switches
 - vi. Control panels
 - vii. Power supplies
 - viii. Batteries
 - ix. Operator interface equipment
 - x. 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
 - viii. Operator interface software
 - ix. Color graphic software
 - x. 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 specified in Section 23 09 93. Indicate alarmed and trended points.
4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
 5. Description of process, report formats, and checklists to be used in Section 23 09 23 Article 3.17 (Control System Demonstration and Acceptance).
- B. Schedules
1. Within one month of contract award, provide a schedule of the work indicating the following:
 - a. Intended sequence of work items
 - b. Start date of each work item
 - c. Duration of each work item
 - d. Planned delivery dates for ordered material and equipment and expected lead times
 - e. Milestones indicating possible restraints on work by other trades or situations
 2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.
- C. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents of the documents shall be submitted for approval prior to final completion and shall include:
1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
 2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Section 23 09 23 Article 3.17 (Control System Demonstration and Acceptance).
 3. Operation and Maintenance (O&M) Manual.
 4. As-built versions of submittal product data.
 5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
 6. 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.
 7. 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.
 8. 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.
 9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
 10. Graphic files, programs, and database on magnetic or optical media.
 11. List of recommended spare parts with part numbers and suppliers.

- 12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - 13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
 - 14. Licenses, guarantees, and warranty documents for equipment and systems.
 - 15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- D. 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.

1.8 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. Provide updates to operator workstation or 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.
 - 5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

1.9 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

1.10 Definitions

Term	Definition
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Term	Definition
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.
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	Microprocessor-based control including Analog/Digital conversion and program logic.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols.
Local Area Network	Computer or control system communications network limited to local building or campus.
Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
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	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.
Wiring	Raceway, fittings, wire, boxes and related items.

PART 2: PRODUCTS

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 unified control network. A gateway (translator) shall communicate with third-party equipment furnished or installed by others.
- B. Install new wiring and network devices as required to provide a complete and workable control network.
- C. Use existing Ethernet backbone for network segments marked "existing" on project drawings.
- 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 control strategies specified in Section 23 09 93. 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. System shall automatically synchronize controller time clocks daily from an operator-designated controller 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 input and output objects with additional 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 specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. 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 SSL (Secure Socket Layer) 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. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.
- B. In addition to the primary operator interface, the system shall include a secondary interface compatible with a locally available commercial wireless network and viewable on a commercially available wireless device such as a Wireless Access Protocol (WAP) enabled cellular telephone. This secondary interface may be text-based and shall provide a summary of the most important data. As a minimum, the following capabilities shall be provided through this interface:
1. An operator authentication system that requires an operator to log in before viewing or editing any data, and which can be configured to limit the privileges of an individual operator.
 2. The ability to view and acknowledge any alarm in the system. Alarms or links to alarms shall be provided on a contiguous list so the operator can quickly view all alarms.
 3. A summary page or pages for each piece of equipment in the system. This page shall include the current values of all critical I/O points and shall allow the operator to lock binary points on or off and to lock analog points to any value within their range.
 4. Navigation links that allow the operator to quickly navigate from the home screen to any piece of equipment in the system, and then return to the home screen. These links may be

arranged in a hierarchical fashion, such as navigating from the home screen to a particular building, then to a specific floor in the building, and then to a specific room or piece of equipment.

- C. Communication. Workstation or web server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol.
- D. Hardware. Each workstation or web server shall consist of the following:
 - 1. Computer. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document. The following hardware requirements also apply:
 - a. The hard disk shall have sufficient memory to store:
 - i. All required operator workstation software.
 - ii. A DDC database at least twice the size of the delivered system database.
 - iii. One year of 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. Dual or Quad Core Processor
 - ii. 6 GB RAM
 - iii. 500 GB hard disk providing data at 3.0 Gb/sec
 - iv. 16x DVD-RW drive
 - v. Serial, parallel, and network communication ports and cables as required for proper DDC system operation
- E. System Software.
 - 1. Operating System. Web server or workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the DDC System manufacturers minimum requirements for their software. Typically acceptable systems include Microsoft Windows7, Microsoft Vista, Microsoft Windows XP Pro, Windows Server 2003 or 2008, Red Hat Enterprise Linux, or Ubuntu Desktop 10.04.
 - 2. 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. 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.
 - b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
 - c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
 - d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. 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 (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

3. 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 that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
 4. 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, coils, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
- F. 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 standard IBM-compatible PCs 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 protection. Operators shall be able to configure the system.
 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. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
 - c. 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 specified in Sequences of Operation.

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.
 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 page, 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.
 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. 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.
 - iii. Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.
 15. 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.
- G. 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 and 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.
 - 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.
- H. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.4 Controller Software

- A. Furnish the following applications for building and energy management. All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.
- B. System Security. See Paragraph 2.3.E.5 (Security) and Paragraph 2.3.E.14.c.iii (Operator Activity).

- C. 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:
 - 1. 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).
 - 2. 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.
 - 3. 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.
- D. 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.
- E. 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.
- F. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.
- G. 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.
- H. 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.
- I. Demand Limiting.
 - 1. 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.
 - 2. 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 Section 23 09 93 (Sequences of Operation). When demand drops below adjustable levels, system shall restore loads as specified.
- J. 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 23 09 93 (Sequences of Operation).
- K. 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.
- L. 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.
- M. Energy Calculations.
 - 1. The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
 - 2. 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.
- N. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

- O. 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.
- P. 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 specified in Section 23 09 93 (Sequence of Operations).

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 in Section 23 09 23 Article 1.9 (System Performance).
- B. Communication
 - 1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
 - 2. Signal Management. BC and ASC operating systems shall 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.
 - 3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
 - 4. Stand-Alone Operation. Each piece of equipment specified in Section 23 09 93 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.
- C. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
 - 1. 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).
 - 2. 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).
- D. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.
- E. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.
- F. 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.
- G. Memory.
 - 1. Controller memory shall support operating system, database, and programming requirements.
 - 2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

3. Each ASC and SA 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.
- H. 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. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
- I. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.6 Input and Output Interface

- A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.
- 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. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. 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. System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system

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 Auxiliary Control Devices

- A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follow.
1. Type. Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.
 - a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
 - b. Other modulating dampers shall be opposed-blade.
 - c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.
 2. Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (1/8 in.) extruded aluminum with reinforced corner bracing.
 3. Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).
 4. Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
 5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m² (10 cfm per ft²) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
 6. Sections. Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.
 7. Modulating dampers shall provide a linear flow characteristic where possible.
 8. Linkages. Dampers shall have exposed linkages.
- B. Electric Damper and Valve Actuators.
1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
 2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
 3. Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
 4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.
- C. Binary Temperature Devices.
1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
 3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.
- D. Temperature Sensors.
1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
 2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m²(10 ft²) of duct cross-section.
 3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
 4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
 5. Differential Sensors. Provide matched sensors for differential temperature measurement.
- E. Humidity Sensors.
1. Duct and room sensors shall have a sensing range of 20%–80%.
 2. Duct sensors shall have a sampling chamber.
 3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
 4. Humidity sensors shall not drift more than 1% of full scale annually.
- F. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
 2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- G. Relays.
1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

- H. Override Timers.
 - 1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.
- I. Current Transmitters.
 - 1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - 2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
 - 3. Unit shall be split-core type for clamp-on installation on existing wiring.
- J. Current Transformers.
 - 1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
 - 2. Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output.
 - 3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.
- K. Voltage Transmitters.
 - 1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.
 - 2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.
 - 3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.
- L. Voltage Transformers.
 - 1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
 - 2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide $\pm 0.5\%$ accuracy at 24 Vac and 5 VA load.
 - 3. Windings (except for terminals) shall be completely enclosed with metal or plastic.
- M. Power Monitors.
 - 1. Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.
 - 2. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
 - 3. Under voltage/phase monitor circuitry.
 - 4. NEMA 1 enclosure.
 - 5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.
- N. Current Switches.
 - 1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.
- O. Pressure Transducers.
 - 1. Transducers shall have linear output signal and field-adjustable zero and span.

2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
- P. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- Q. Occupancy Sensors. Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.
- R. Local Control Panels.
 1. 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.
 2. 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.
 3. 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.

2.10 Fiber Optic Cable System

- A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.
- B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

PART 3: EXECUTION

3.1 Examination

- A. 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.
- B. 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. Submittals. See Section 23 09 23 Article 1.10 (Submittals).
- C. 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.
- D. 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 Section 23 09 93 (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 Section 23 09 93 (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.
- E. 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 Existing Equipment

- A. Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.
- B. Local Control Panels. Remove and deliver existing control panels to Owner.
- C. Repair. Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.
- D. Indicator Gauges. Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.
- E. Room Thermostats. Remove and deliver existing room thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.
- F. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.
- G. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.
- H. Damper Actuators, Linkages, and Appurtenances. Remove and deliver existing damper actuators, linkages and appurtenances to Owner.
- I. Existing System Operating Schedule. The mechanical system must remain in operation and shall maintain space comfort at all times between the hours of 6 a.m. and 9 p.m., Monday through Friday. No modifications to the system shall cause mechanical system to be shut down for more than 15 minutes or to fail to maintain space comfort conditions during any such period. Perform cut-over of controls that cannot meet these conditions outside of operational hours.

- J. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation
- K. Install control panels where shown.
- L. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.
- M. Patch holes and finish to match existing walls.

3.7 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.

3.8 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. All communication wiring shall be labeled to indicate origination and destination data.
- J. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.9 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.

3.10 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 (1 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 height-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.
- 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.

3.11 Flow Switch Installation

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

3.12 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.

3.13 Warning Labels

- A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.
1. Labels shall use white lettering (12-point type or larger) on a red background.
 2. Warning labels shall read as follows.

CAUTION

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

- B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
1. Labels shall use white lettering (12-point type or larger) on a red background.
 2. Warning labels shall read as follows.

CAUTION

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.14 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. Permanently label or code each point of field terminal strips to show the instrument or item served.
- C. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- D. 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.
- E. Identify room sensors related to terminal boxes with nameplates.
- F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
- G. Identifiers shall match record documents.

3.15 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 Section 23 09 93 (Sequences of Operation).

3.16 Programming

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging.
- B. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See Section 23 09 93 (Sequences of Operation). If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix B to Section 23 09 93 may be used.
- 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 in Section 23 09 93.
 - 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.

3.17 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, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to 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

3.18 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."

3.19 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.

3.20 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.

3.21 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 Controls Communication Protocol

- A. General. The electronic controls packaged with this equipment shall communicate with the building direct digital control (DDC) system. The DDC system shall communicate with these controls to read the information and change the control setpoints as shown in the points list, sequences of operation, and control schematics.
- B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.
- C. I/O Capacity. The controller shall contain sufficient I/ O capacity to control the target system.
- D. The Controller shall have a physical connection for a laptop computer or a portable operator's tool.
- E. Environment. The hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 40°C to 60°C (40°F to 140°F).
 - 2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).
- F. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.
- G. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

- H. Power. Controller shall be able to operate at 90% to 110% of nominal voltage rating.
- I. Transformer. Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.25 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.

APPENDIX A: Glossary of Terms

Terms used within the Specification Text:

- **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 sub-net.

- **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/IP:**

An approved BACnet network type which uses an Ethernet carrier and IP addressing.

- **BACnet MS/TP:**

An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

- **BACnet over ARCNET:**

An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configu-

ration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

- **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.

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

A control system in which a digital computer or microprocessor is directly connected to the dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an electronic controller.

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

A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

- **Smart Actuator (SA):**

An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

- **Smart Sensor (SS):**

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.)

- **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.

Terms used within the Sequences of Operation:

- **adj.**

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

- **AI, AO, etc. (Column Headings on Points List)**

AI = Analog Input. A physical input to the control module.

AO = Analog Output. A physical output from the control module.

AV = 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.

BI = Binary Input. A physical input to the control module.

BO = Binary Output. A physical output from the control module.

BV = 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.

Loop = A 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.

Sched = 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.)

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.

Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

- **KW Demand Limiting: ***

An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold.

When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

- **Occupant Override Switch, or Timed Local Override:**

A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time.

When the override time expires, the zone returns to its unoccupied state.

- **Occupant Setpoint Adjustment:**

A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

- **Optimal Start-Up: ***

A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied.

In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint.

The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity.

A distributed system must use Run on Request with Optimal Start. (See below.)

- **Requested, or Run on Request: ***

A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule.

The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.

For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller.

The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

- **Trim and Respond, or Setpoint Optimization: ***

A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service.

The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint.

For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

Contracting Terms:

- **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.

- **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.

- **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.

- **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.

APPENDIX B: Abbreviations

The following abbreviations may be used in graphics, schematics, point names, and other UI applications where space is at a premium.

AC - Air Conditioning
ACU - Air Conditioning Unit
AHU - Air Handling Unit
AI - Analog Input
AO - Analog Output
AUTO - Automatic
AUX - Auxiliary
BI - Binary Input
BO - Binary Output
C - Common
CHW - Chilled Water
CHWP - Chilled Water Pump
CHWR - Chilled Water Return
CHWS - Chilled Water Supply
COND - Condenser
CW - Condenser Water
CWP - Condenser Water Pump
CWR - Condenser Water Return
CWS - Condenser Water Supply
DA - Discharge Air
EA - Exhaust Air
EF - Exhaust Fan
EVAP - Evaporators
FCU - Fan Coil Unit
HOA - Hand / Off / Auto
HP - Heat Pump
HRU - Heat Recovery Unit
HTEX - Heat Exchanger
HW - Hot Water

HWP - Hot Water Pump
HWR - Hot Water Return
HWS - Hot Water Supply
MAX - Maximum
MIN - Minimum
MISC - Miscellaneous
NC - Normally Closed
NO - Normally Open
OA - Outdoor Air
PIU - Powered Induction Unit
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
VVTU - Variable Volume Terminal Unit
W/ - with
W/O - without
WSHP - Water Source Heat Pump

POINTS LIST														
SYSTEM POINT DESCRIPTION		POINT TYPE					ALARMS				NOTES:			
		GRAPHIC	HARDWARE INPUT	HARDWARE OUTPUT	SOFTWARE POINT	DEFAULT VALUE	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC		SENSOR FAIL	COMMUNICATION FAIL	DIAGNOSTICS
CONSTANT VOLUME AIR HANDLER UNIT, WITH GAS HEATING/DX COOLING														
ZONE SENSOR	ZONE TEMPERATURE (THERM)	X	AI				X	X		X			SENSOR FAILURE	
	ZONE TEMPERATURE SETPOINT ON/CANCEL		AI							X			SENSOR FAILURE	
	SUPPLY FAN START/STOP	X		BO										
	HEATER GAS VALVE	X		BO										NOTE 2
	DX COOLING	X		BO										NOTE 2
	OUTSIDE AIR DAMPER													
	COOLING COIL DISCHARGE TEMPERATURE													
	MIXED AIR TEMPERATURE													
	DISCHARGE AIR TEMPERATURE	X	AI				X	X		X			SENSOR FAILURE	
	LOW LIMIT THERMOSTAT													
	SUPPLY FAN STATUS	X	BI						X	X			FAN FAILURE	
	UNIT ALARM STATUS	X	BI						X					
	OCCUPIED COOLING SETPOINT				X	74°F								
	OCCUPIED HEATING SETPOINT				X	70°F								
	OCCUPIED STANDBY COOLING SETPOINT				X	80°F								
	OCCUPIED STANDBY HEATING SETPOINT				X	65°F								
	UNOCCUPIED COOLING SETPOINT				X	85°F								
	UNOCCUPIED HEATING SETPOINT				X	60°F								
	OCCUPIED BYPASS TIMER				X	2.0 HRS								
	MIXED AIR TEMPERATURE LOW LIMIT SETPOINT													
	DISCHARGE AIR COOLING SETPOINT													
	DISCHARGE AIR HEATING SETPOINT													
	BAS COMMUNICATION STATE				X						X			NOTE 1
GENERAL NOTES:														
1. DISPLAYED AT THE BAS USER INTERFACE IF PRESENT														
2. PROVIDE HEATING AND COOLING STAGES AS REQUIRED														

SEQUENCE OF OPERATIONS

BUILDING AUTOMATION SYSTEM INTERFACE:

THE BUILDING AUTOMATION SYSTEM (BAS) SHALL SEND THE CONTROLLER OCCUPIED BYPASS, MORNING WARM-UP/PRE-COOL, OCCUPIED/UNOCCUPIED AND HEAT/COOL MODES. IF A BAS IS NOT PRESENT, OR COMMUNICATION IS LOST WITH THE BAS THE CONTROLLER SHALL OPERATE USING DEFAULT MODES AND SETPOINTS.

OCCUPIED:

DURING OCCUPIED PERIODS, THE SUPPLY FAN SHALL RUN CONTINUOUSLY AND THE OUTSIDE AIR DAMPER SHALL OPEN TO MAINTAIN MINIMUM VENTILATION REQUIREMENTS. THE DX COOLING AND HEATER SHALL STAGE TO MAINTAIN THE DISCHARGE AIR TEMPERATURE SETPOINT. THE DISCHARGE AIR TEMPERATURE SETPOINT SHALL BE DYNAMICALLY RESET BASED ON THE DEVIATION OF ACTUAL SPACE TEMPERATURE FROM THE ACTIVE SPACE TEMPERATURE SETPOINT. IF THE DISCHARGE AIR TEMPERATURE SENSOR FAILS THE DX COOLING SHALL STAGE AND THE GAS VALVE SHALL STAGE TO MAINTAIN THE ACTIVE SPACE TEMPERATURE SETPOINT AND AN ALARM SHALL BE ANNUNCIATED AT THE BAS. IF THE DISCHARGE AIR TEMPERATURE SENSOR AND THE SPACE TEMPERATURE SENSOR FAIL THE DX COOLING SHALL BE DISABLED, THE HEATER VALVE SHALL CLOSE AND AN ALARM SHALL BE ANNUNCIATED AT THE BAS.

UNOCCUPIED:

WHEN THE SPACE TEMPERATURE IS BELOW THE UNOCCUPIED HEATING SETPOINT OF 60.0 DEG. F (ADJ.) THE SUPPLY FAN SHALL START, THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED AND THE HEATER SHALL RUN. WHEN THE SPACE TEMPERATURE RISES ABOVE THE UNOCCUPIED HEATING SETPOINT OF 60.0 DEG. F (ADJ.) PLUS THE UNOCCUPIED DIFFERENTIAL OF 4.0 DEG. F (ADJ.) THE SUPPLY FAN SHALL STOP AND THE HEATER SHALL BE OFF. WHEN THE SPACE TEMPERATURE IS ABOVE THE UNOCCUPIED COOLING SETPOINT OF 85.0 DEG. F (ADJ.) THE SUPPLY FAN SHALL START, THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED AND THE DX COOLING SHALL BE ENABLED. WHEN THE SPACE TEMPERATURE FALLS BELOW THE UNOCCUPIED COOLING SETPOINT OF 85.0 DEG. F (ADJ.) MINUS THE UNOCCUPIED DIFFERENTIAL OF 4.0 DEG. F (ADJ.) THE SUPPLY FAN SHALL STOP, THE DX COOLING SHALL BE DISABLED AND THE OUTSIDE AIR DAMPER SHALL CLOSE.

OPTIMAL START:

THE BAS SHALL MONITOR THE SCHEDULED OCCUPIED TIME, OCCUPIED SPACE SETPOINTS AND SPACE TEMPERATURE TO CALCULATE WHEN THE OPTIMAL START OCCURS.

MORNING WARM-UP MODE:

DURING OPTIMAL START, IF THE SPACE TEMPERATURE IS BELOW THE OCCUPIED HEATING SETPOINT A MORNING WARM-UP MODE SHALL BE ACTIVATED. WHEN MORNING WARM-UP IS INITIATED THE UNIT SHALL ENABLE THE HEATING AND SUPPLY FAN. THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED. WHEN THE SPACE TEMPERATURE REACHES THE OCCUPIED HEATING SETPOINT (ADJ.), THE UNIT SHALL TRANSITION TO THE OCCUPIED MODE.

PRE-COOL MODE:

DURING OPTIMAL START, IF THE SPACE TEMPERATURE IS ABOVE THE OCCUPIED COOLING SETPOINT, PRE-COOL MODE SHALL BE ACTIVATED. WHEN PRE-COOL IS INITIATED THE UNIT SHALL ENABLE THE FAN AND COOLING. THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED. WHEN THE SPACE TEMPERATURE REACHES OCCUPIED COOLING SETPOINT (ADJ.), THE UNIT SHALL TRANSITION TO THE OCCUPIED MODE.

OPTIMAL STOP:

THE BAS SHALL MONITOR THE SCHEDULED UNOCCUPIED TIME, OCCUPIED SETPOINTS AND SPACE TEMPERATURE TO CALCULATE WHEN THE OPTIMAL STOP OCCURS. WHEN THE OPTIMAL STOP MODE IS ACTIVE THE UNIT CONTROLLER SHALL MAINTAIN THE SPACE TEMPERATURE TO THE SPACE TEMPERATURE OFFSET SETPOINT. OUTSIDE AIR DAMPER SHALL REMAIN ENABLED TO PROVIDE VENTILATION.

OCCUPIED BYPASS:

THE BAS SHALL MONITOR THE STATUS OF THE "ON" AND "CANCEL" BUTTONS OF THE SPACE TEMPERATURE SENSOR. WHEN AN OCCUPIED BYPASS REQUEST IS RECEIVED FROM A SPACE SENSOR, THE UNIT SHALL TRANSITION FROM ITS CURRENT OCCUPANCY MODE TO OCCUPIED BYPASS MODE AND THE UNIT SHALL MAINTAIN THE SPACE TEMPERATURE TO THE OCCUPIED SETPOINTS (ADJ.).

HEAT/COOL MODE:

WHEN THE SPACE TEMPERATURE RISES ABOVE THE OCCUPIED COOLING SETPOINT THE MODE SHALL TRANSITION TO COOLING. WHEN THE SPACE TEMPERATURE FALLS BELOW THE OCCUPIED HEATING SETPOINT THE MODE SHALL TRANSITION TO HEATING. WHEN THE SPACE TEMPERATURE IS ABOVE THE OCCUPIED COOLING SETPOINT OR BELOW THE OCCUPIED HEATING SETPOINT THE MODE SHALL REMAIN IN ITS LAST STATE. IF THE SPACE TEMPERATURE SENSOR FAILS THE MODE SHALL REMAIN IN ITS LAST STATE AND AN ALARM SHALL BE ANNUNCIATED AT THE BAS. IF THE LOCAL AND COMMUNICATED SETPOINTS FAIL THE CONTROLLER SHALL DISABLE THE SUPPLY FAN AND AN ALARM SHALL BE ANNUNCIATED AT THE BAS.

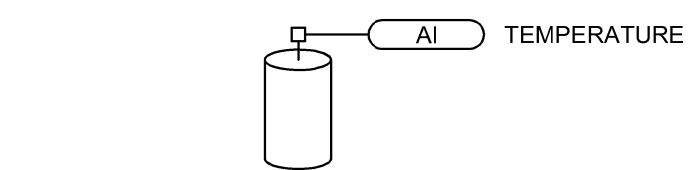
FREEZE PROTECTION:

A HARDWIRED, LOW LIMIT TEMPERATURE SWITCH SHALL BE ELECTRICALLY INTERLOCKED WITH THE MOTOR STARTER. IF THE LOW LIMIT TEMPERATURE SWITCH IS TRIPPED 38.0 DEG. F (ADJ.), THE OUTSIDE AIR DAMPER SHALL CLOSE, ALL VALVES SHALL OPEN TO 100% (ADJUST PER CLIMATE), ALL STAGES OF DX COOLING SHALL BE DISABLED AND AN ALARM SHALL BE ANNUNCIATED AT THE BAS. A MANUAL RESET OF THE LOW LIMIT TEMPERATURE SWITCH SHALL BE REQUIRED TO RESTART THE FAN.

UNIT ALARM STATUS:

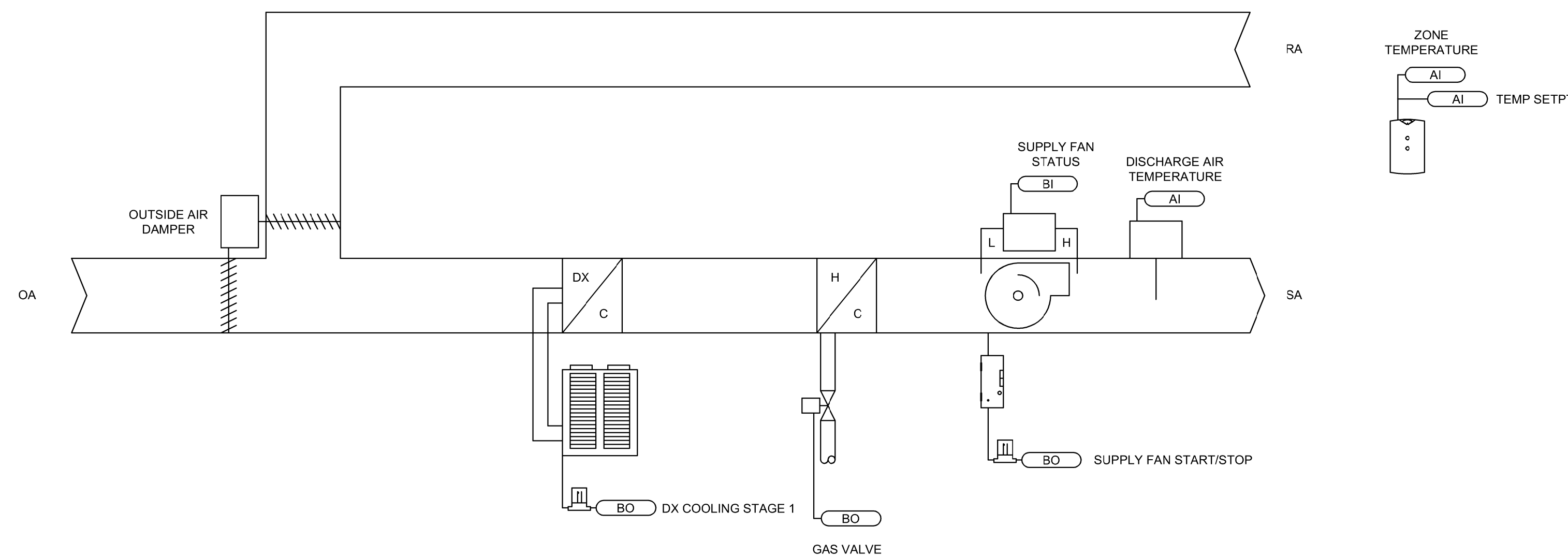
EACH UNIT HAS AN ON-BOARD CONTROLLER. IF THE CONTROLLER IS IN ALARM, AN ALARM SHALL BE ANNUNCIATED AT THE BAS.

TYPICAL OF (3) DOMESTIC WATER HEATERS

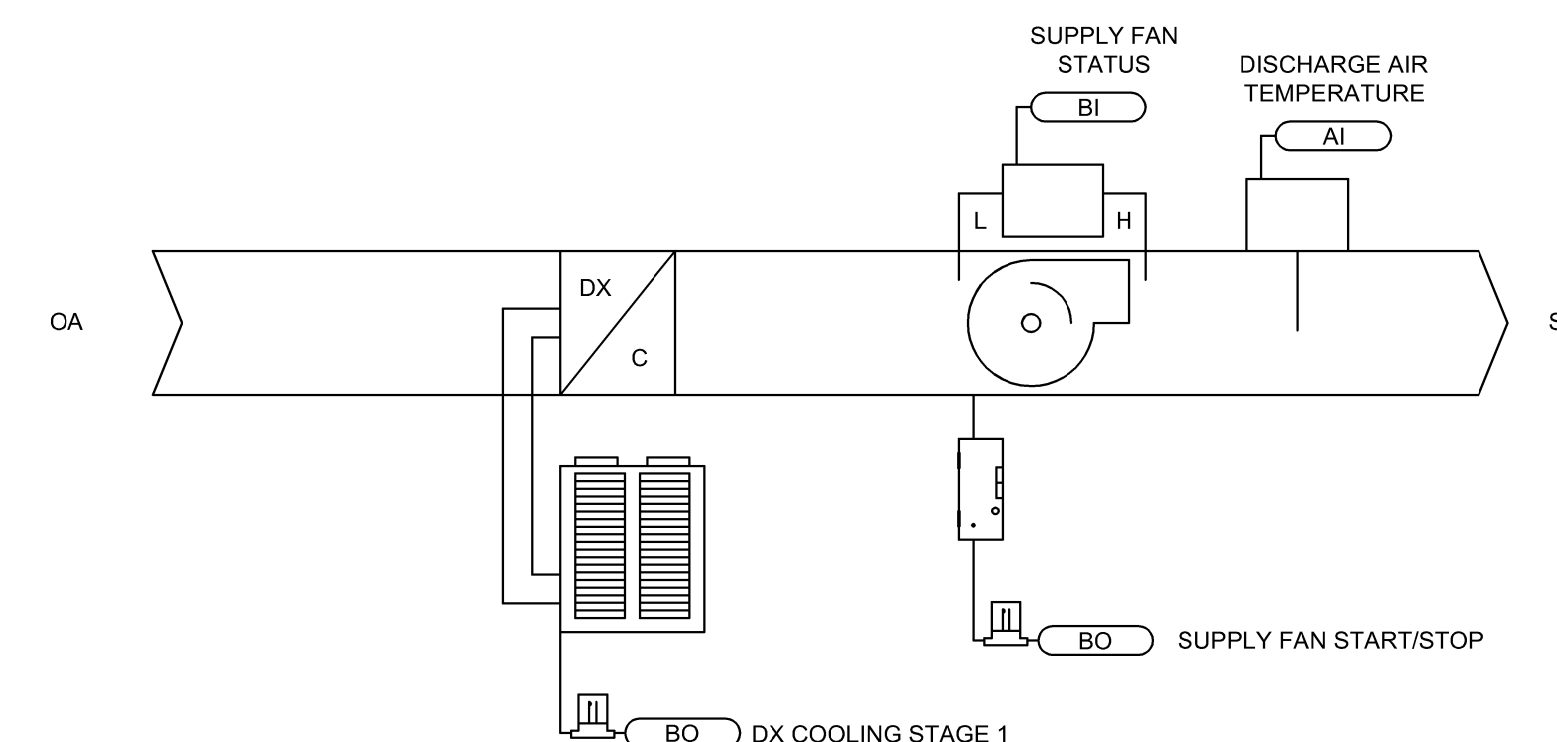


THE BAS WILL MONITOR THE WATER HEATER TEMPERATURE.

TYPICAL OF (19) NEW AAO AND (6) EXISTING TRANE RTU's



TYPICAL OF (6) CRAC's



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ENGINEER OF RECORD

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PROJECT NO.: GRDA # 13032-05
DATE: 08/21/2013

DRAWN BY: RCW
CHECKED BY: MDO

GRDA
Grand River Dam Authority
**ENGINEERING & TECHNOLOGY CENTER REMODEL
TULSA, OKLAHOMA**

ISSUE/ REVISIONS

08/21/2013 FOR CONSTRUCTION
08/12/2013 REVISION 1

**ENGINEERING & TECHNOLOGY CENTER REMODEL
TULSA, OKLAHOMA**
FOR:
GRAND RIVER DAM AUTHORITY

M701

CONTROLS/SCHEMATICS