AUSTIN Independent School District | Contract and Procurement Services

Request for Qualifications
19RFQ083 Building Automation System

Date	Event
November 27, 2018 December 4, 2018	Advertise/Issue Date
December 6, 2018	Pre-Proposal Conference at **10:00 AM AISD Construction Management Department 812 San Antonio Street Suite 200 Austin, Texas 78701**
January 4, 2018	Due Date for Questions by 5:00 pm
January 7, 2018	Questions and Answers posted on our website
January 10, 2018	**RFQ opening / due date at 2:00 pm CST**
December 17, 2018	AISD Board Meeting for review/approval

Deliver Sealed Proposals to:	**Contact:**
Austin ISD **Contract & Procurement Services** **1111 West 6th Street** **Building A, Suite 330** **Austin, TX 78703**	**Jennifer Nix** **Contract & Procurement Services** **jennifer.nix@austinisd.org**

- Questions must be submitted via e-mail to the contact person listed above.
  In the e-mail subject line, type: *Questions 19RFQ083 Building Automation Systems*
- Q & A and Addenda will be posted on our website: www.austinisd.org/cp/bids
- Proposals are due no later than 2:00 pm on the date indicated. Your proposals must be delivered by mail or hand delivery in a sealed envelope or carton. Proposals received after the specified time shall not be considered.
- **Please submit the following:**
  Required
  - One (1) hard copy marked "original" – include signed "required" forms

  Requested
  - One (1) digital copy on a flash drive – include signed "required" forms
  - One (1) hard copy marked "copy"
- FAX, e-mail or other electronic proposals **will not be accepted.**
- Proposals must be plainly marked with **name and address of the Offeror and the RFQ number and Title above**.

This solicitation is a request for qualifications for professional services under Texas Government Code 2270.

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1. SCOPE OF WORK

1.1. Project Description

In November of 2017, Austin voters approved a $1-billion Bond to include: new/modernized campus facilities; improvements to address overcrowding and critical needs; and districtwide improvements to technology for teachers and students and transportation within Austin Independent School District (AISD).

As part of the 2017 Bond Projects, AISD has determined the need to pre-select provider(s) of Building Automation Systems (BAS) in order to ensure adequate workforce capacity to complete the work within the scheduled construction period, while providing a common operational platform for ease of use by facilities personnel.

The District has elected to use the Request for Qualification (RFQ) process to select up to five BAS providers who can demonstrate the capability to provide the services required for new construction and renovation projects.

The selected HVAC control contractor will provide the services required for these projects as a Subcontractor to each project's General Contractor.

Other BAS-only projects may be developed directly by the Design Teams or AISD and not include a General Contractor.

1.2. Scope of Contracted Services

1.2.1 New Schools:

New BAS will be provided for the following new construction/major renovation projects:

1. Ann Richards School for Young Women Leaders Campus Modernization. Anticipated opening: August 2021
2. New Southwest Elementary School. Anticipated opening: August 2020
3. Blazier Relief Elementary/Middle School. Anticipated opening: August 2020
4. Modernized Eastside High School. Anticipated opening: July 2020
5. Govalle Elementary School. Anticipated opening: January 2020
6. T.A. Brown Elementary School. Anticipated opening: January 2020
7. Doss Elementary School. Anticipated opening: August 2020
8. Murchison Middle School Addition. Anticipated opening: December 2020
9. Menchaca Elementary School. Anticipated opening: January 2020
10. Bowie High School. Anticipated opening: July 2022
11. LBJ Vertical Team Elementary Modernization. Anticipated opening: August 2020
12. Rosedale School. Anticipated opening: August 2021
13. Austin High School. Anticipated opening: August 2022
14. Brentwood Elementary School. Anticipated opening: August 2022
15. Casis Elementary School Campus Modernization. Anticipated opening: August 2022
16. Eastside Memorial Vertical Team Elementary Modernization. Anticipated opening: August 2021
17. LASA move to Eastside – Interior renovations. Anticipated opening: August 2020

18. LBJ Early College Medical High School – Interior renovations. Anticipated opening: August 2021
19. New Northeast Middle School. Anticipated opening: August 2022
20. Hill Elementary School Addition and Renovation. Anticipated opening: August 2022

1.2.2 Mechanical Renovations:

The same provider(s) may be asked to propose on BAS work associated with mechanical renovations in existing buildings throughout the District.

1.2.3 Operator's Station

The central District Operator Workstation computer is being provided by the Owner as part of a separate project. Contractor shall utilize this computer for graphics, control programs, alarm reporting, trending reports, etc., providing for web-based interconnection with their systems.

1.2.4 Technical Requirements

The District's Standard Specifications outlining the technical requirements for the BAS are provided in Appendix A. Specific sequences and points lists will be developed by the Design Team and/or Owner for each project.

2. PROPOSAL PROCESS

2.1. General

2.1.1. Evaluation of Qualifications

Qualifications will be evaluated by an evaluation team selected by AISD. The evaluation will be in accordance with Section 5 of this document, Evaluation of Qualifications, and may include requests by the team for additional information and interviews to determine and clarify the experience and responsibility of the proposer. The evaluation team will make a recommendation to the AISD Board (Board), who will make the final decision to select the contractor.

2.1.2. Obligation to Award

The issuance of this RFQ, and the receipt and evaluation of qualifications does not obligate AISD to award a contract. AISD will not pay any costs incurred in responding to this RFQ. AISD may cancel this procurement without liability at any time prior to AISD's execution of a contract.

2.1.3. Commencement of Work

The successful proposer may commence work only after AISD delivers a fully executed contract to that proposer.

2.2. Pre-Qualifications Interpretation of Contract Documents

2.2.1. Changes to RFQ

2.2.1.1. AISD reserves the right to make changes to the RFQ. Changes will be made by written addendum which will be issued on https://www.austinisd.org/cp/bids and https://planroom.millerids.com/

2.3. Public Disclosure of Qualifications

2.3.1. Any information provided to AISD pursuant to this RFQ is subject to public disclosure pursuant to Texas's public records laws (ORS 192.410 to 192.505).

2.3.2. The general requirement for public disclosure is subject to a number of exemptions. Each page containing information deemed by the proposer as necessary to remain exempt from public disclosure after qualifications have been evaluated (e.g., pages containing trade secret, economic development information, etc.) should be plainly marked. Marked pages should be placed in a group separate from the remainder of the qualifications.

2.3.3. The fact that a proposer marks and segregates certain information as exempt from disclosure does not mean that the information is necessarily exempt. AISD will make an independent determination regarding exemptions applicable to information that has been properly marked and segregated. Information that has not been properly marked and segregated may be disclosed in response to a public records request. When exempt information is mixed with nonexempt information, the nonexempt information must be disclosed. AISD will redact pages

that include both exempt and nonexempt information to allow disclosure of the nonexempt information.

2.3.4. Unless expressly provided otherwise in this RFQ or in a separate communication, AISD does not agree to withhold from public disclosure any information submitted in confidence by a proposer unless the information is otherwise exempt under Texas law. AISD considers qualifications submitted in response to this RFQ to be submitted in confidence only until AISD's evaluation is complete and agrees not to disclose qualifications until AISD has completed its evaluation of all qualifications and publicly announced the results.

2.4. Submission of Qualifications

Each proposer's submission in response to this RFQ must:

2.4.1.1. Include one original (marked as such), 1 copy, and 1 digital version in pdf format on a USB;

2.4.1.2. Include the completed and executed Qualifications form (Section 4 of this RFQ) as the first page of the original submission of each copy;

2.4.1.3. Be submitted in a sealed envelope that is plainly marked "Qualifications to Provide Building Automation Systems– Austin Independent School District" and bears the proposer's name, address, telephone number, and email address; and

2.5. Schedule

2.5.1. Period of Irrevocability

Qualifications shall be offers that are irrevocable for a period of sixty (60) calendar days after the time and date proposals are due. Qualifications shall contain the name, address and telephone number of an individual or individuals with authority to bind the company during the period in which the qualifications will be evaluated.

3. QUALIFICATIONS

3.1. Preparation

Qualifications shall be prepared simply and economically, providing a straightforward, concise description of the proposer's ability to satisfy the requirements of this RFQ.

AISD will not be liable for any expense incurred in the preparation of qualifications.

Proposers are encouraged to use creativity and to provide complete information in their written qualifications. However, except as provided otherwise below, a qualifications response to section 3.2.2 shall be written on 8.5" X 11" paper, in a font size no smaller than 10 points and shall not exceed 40 single-sided pages, including pictures or diagrams. If a proposer exceeds the page limit in responding to section 3.2.2, AISD will consider the information on the first 40 pages, and may decline to consider information beyond the 40th page.

3.2. Format

Qualifications shall conform to the following format:

3.2.1. Qualification Form

The qualification form is included as Section 4 of this RFQ. It shall be completed, executed and included as the first page of the qualifications. The qualification form will not be counted against the 40 page limit for qualifications.

3.2.2. Required Submissions

Qualifications shall contain the following information in the order listed below. Concise and direct responses are encouraged.

1. Manufacturer History and Stability

a. Manufacturer history and future outlook.
b. Number of years producing HVAC control systems.

2. System Functionality

a. Indicate how proposed system meets functional requirements of elementary, middle, and high school level facilities, with air handling systems, terminal units, chillers, cooling towers, ground source heat pumps, boilers, hydronic pumps, and water heaters, with facilities distributed throughout Austin.
b. AISD wishes to integrate the proposed HVAC controls system with that of on-going projects. Discuss the capabilities of the proposed system in achieving this goal.
c. Discuss the ability for providing Web-based (thin-client) access for the proposed system.
d. Outline the interoperability features of the proposed system.
e. Indicate the number of years that the proposed system been in production.
f. Indicate the number of similar systems that have been installed in Texas for K-12 School Districts.
g. Discuss future upgrade plans for proposed systems.

3. Technical Requirements

Provide documentation for the following:

a. Control system architecture
b. Communications compatibility with other systems that are BacNet compliant (BTL level 5) communications protocol.
c. Description of the programming tool and language used to program the proposed controllers.
d. Operator interface/workstation graphics.
e. System Specifications.

4. Contractor Information and Experience

Provide documentation for the following:

a. Location of main and branch offices with staff that would be involved in project.
b. Indicate number of years that contractor has installed systems similar to that required on this project. Minimum 5 years.
c. Provide resumes for key staff anticipated to perform work on this project.
d. Provide three references from School Districts (K-12) on past projects where similar systems have been installed, and two references from other Owners with similar systems.

5. Contractor Support and Service

Provide documentation for the following:

a. Provide example of typical agenda for Owner training for new system installation.
b. Present and describe the Contractor's ability and commitment to providing ongoing technical support and service after initial system installation.
c. Describe the experience, availability, and location of service staff.
d. Discuss availability for emergency support and service.
e. Provide examples of typical unit prices for current service contracts.
f. Provide three references from School Districts with current service contracts, and two references from other Owners with current service contracts.

3.2.2.3. Contract Format

a. The sample Agreement presented in Appendix B and General Conditions presented in Appendix C will be the basis of the agreement for services provided by the selected proposer on the project. The proposer shall identify in its qualifications all exceptions and proposed revisions to the Agreement.
b. AISD will consider all exceptions and proposed revisions but AISD will not be obligated to accept them.

4. QUALIFICATION FORM

AUSTIN INDEPENDENT SCHOOL DISTRICT

BUILDING AUTOMATION SYSTEMS (BAS)

The undersigned proposer submits this proposal in response to the Austin Independent School District's Request for Qualifications (RFQ) dated November 27, 2018 for the contract named above. The proposer warrants that proposer has carefully reviewed the RFQ and that this proposal represents proposer's full response to the requirements described in the RFQ. The proposer further warrants that if this proposal is accepted, the proposer will contract with the Austin Independent School District, agrees to all terms and conditions found in the attached contract, and will provide all necessary labor, materials, equipment, and other means required to complete the work in accordance with the requirements of the RFQ and contract documents.

No proposal will be considered unless the proposer is licensed with the State of Texas Construction Contractors Board, pursuant to ORS 701.021 (1), prior to submitting a proposal. The proposer hereby acknowledges the requirement to carry or indicates the ability to obtain the insurance required by the contract documents. Indicate in the affirmative by initialing here: _____

No proposal will be accepted or considered unless the proposer agrees to comply with both State and Federal prevailing wage requirements in ORS 279C.838, ORS 279C.840, and 40 U.S.C. 3141. Indicate intent to comply with these requirements by initialing here: _____

The proposer hereby acknowledges receipt of Addendum Nos. ___ through ___ to this RFQ.

Name of Proposer:

Business Address:

Telephone Number:

Fax Number:

Email Address:

Authorized Signature: _____

Printed/Typed Name:

Title:

Date:

State of Texas Construction Contractors Board License Number:

Note: Complete and execute this form and include as the first page of the proposal.

5. EVALUATION OF QUALIFICATIONS

5.1. General

Proposers for the Building Automation System services will be evaluated and rated based on their written qualifications and interviews, if conducted. Submittal requirements for the qualifications are detailed in section 3. It is AISD's intent to select up to five contractors.

5.2. Competitive Range

An evaluation team will determine which qualifications are within the competitive range in accordance with the evaluation criteria set forth below. Only those qualifications determined within the competitive range will be considered for award.

5.3. Interviews

The evaluation team may choose to interview one or more proposers to assist them with their evaluation. Interviewed proposers should be prepared to respond to questions related specifically to their proposals and other pertinent matters regarding the RFQ.

5.4. Evaluation Criteria

The District evaluation team will consider information provided in the written qualifications and interviews (if conducted), according to the following criteria, to rank the proposers in order of suitability to meet the District's needs. **Proposers are required to organize the written qualifications in numerical order, as described below**. Maximum available points will be 100 and the maximum points available for each evaluation criteria are listed in parenthesis after the criteria.

1. Manufacturer History and Stability (15 points maximum)
2. System Functionality (25 points maximum)
3. Technical Requirements (15 points maximum)
4. Contractor Information and Experience (20 points maximum)
5. Contractor Support and Service (20 points maximum)
6. Completeness and Quality of Response (5 points maximum)

After evaluation by the team, the team will recommend to the Austin Independent School Board that the top-ranked proposers be approved to provide Building Automation System services to the District either under direct contract with the District or through Contractors engaged in construction and/or renovation projects.

The District reserves the right to waive informalities or to reject any and all qualifications.

DIRECT DIGITAL CONTROLS FOR LOCAL BUILDING AUTOMATION SYSTEMS TRIDIUM-BACNET WEB-BASED –SECTION 230926a

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Division 23

1. General Mechanical Requirements
2. Mechanical equipment
3. Piping
4. Variable Frequency Drives (VFDs)
5. Building Automation System Commissioning Requirements

C. Division 26

1. General Electrical Requirements
2. Raceways
3. Disconnect Switches
4. Wiring

D. Division 27

1. Telecommunications cabling

E. Division 28

1. Fire Alarm Systems.

F. Mechanical and electrical drawings: Specifications and drawings are complementary to each other and binding. What is called for by one shall be binding as if called for by both. Should there be a conflict between drawings and specifications regarding a material shown of work described or detailed then the material of work having the greater value shall be provided.

1.2 SUMMARY

A. Provide all hardware, software, materials, labor, and programming for the implementation of a complete standalone Local Building Automation System (BAS) for control of HVAC systems and components.

B. The system shall consist of a network of microprocessor-based, peer-to-peer, networked, distributed devices utilizing the BACnet communication protocol in an open, interoperable system. The system shall include all wiring and control devices, sensors, actuators, valves, dampers, and hardware required for a complete operational system that will achieve the control sequences specified.

C. Provide all programming to achieve specified operational sequences, and development of graphical screens, setup of schedules, trends, logs, alarms, network management, and operational connection of the Network Control Unit (NCU) to the local area network.

D. Access to the Building Automation System for configuration and monitoring shall be performed via a Network Control Unit (NCU) connected to the LAN or WAN.

E. All components of the system shall be BACnet Testing Laboratories (BTL) Certified.

F. System design shall follow pertinent and applicable BACnet guidelines. Controllers that require a master computer or controller to perform basic functions are not acceptable. In the event of a network communication failure, or the loss of any other controller on the BACnet network, the control system shall continue to independently operate under control of the resident program stored in nonvolatile memory as detailed herein.

G. The network infrastructure shall conform to the BACnet published guidelines for network wiring and system architecture. Wire type, distance, termination, and use of routers shall strictly conform to the BACnet wiring standards. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.

H. Mechanical equipment controllers shall include all control points and achieve all control sequences specified while operating under stand-alone control, independently of connection to the network manager.

I. Provide DDC system shop drawings and submittals, participate in submittal review meetings, and obtain final approval of submittal from Owner and Engineer prior to installation of system.

J. Fully test system prior to requesting installation inspection and pre-functional testing by Owner, Engineer, and Commissioning Authority.

K. Schedule competent technical personnel to participate in Commissioning activities.

L. Provide a Schedule of Values for work of this section, that includes the following:

1. Submittals (5%)
2. Materials (35%)
3. Installation (35%)
4. Installation Verification with Owner’s CxA (5%)
5. Programming & Graphics (10%)
6. Point check out and Commissioning with Owner’s CxA (5%)
7. Final O&Ms and As-Built Documentation (5%)

1.3 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than ten seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within eight to ten seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

1.4 ACCEPTABLE CONTRACTORS

A. Pending compliance with this specification, the following firms have been deemed acceptable contractors for the products and services herein specified:

1. To be determined via the RFQ process.

B. Contractor responsible for work under this Section shall be a local factory certified office of the manufacturer of control systems located within 75-mile radius from the job site. Experience requirements below apply only to the local factory certified office.

C. Contractor shall have, as a minimum, five (5) years of documented continuous business experience in the installation of controls, instrumentation and Energy Management Systems.

D. Contractor's local personnel conducting work of this section shall have a minimum of three (3) years of experience in the installation of BACnet systems. Personnel conducting work shall be:

1. Tridium Niagara N4 Certified
2. BACnet Certified Professional

Contractor shall provide evidence of certifications upon request.

E. The installing office shall provide a list of completed and accepted BACnet job references. The references shall include one job from each of the Three (3) years required.

F. Each reference shall include the following: the job name, the job size, the owner with address, contact name and phone number, the general contractor, the mechanical contractor, and the contracting company's system programmer name(s).

G. The Contractor's BACnet Certified personnel shall be directly responsible for all work related to:

1. System design
2. Submittals
3. Programming;
4. Installation Supervision
5. Calibration
6. Checkout
7. Commissioning.

1.5 SUBMITTALS

A. Refer to Division-1 Submittals and Division-23 General Mechanical Work for additional submittal requirements.

B. Scope of Work Summary: Include in submittal package a clear written summary of the scope of control work, including but not limited to the following:

1. Integration with the existing systems (if any) at the facility;
2. Scope of demolition work (if any)
3. Systems to be controlled as part of this work, clearly stating which systems will receive full DDC systems, and which (if any) will receive only timeclock control.

4. Evidence of coordination with manufacturers of equipment provided under the mechanical and electrical scope of work to verify that all required control points and sequences will be implemented, regardless of whether the DDC controls reside in a controller provided by the equipment manufacturer or the controls contractor.

C. Product Data:

1. DDC System Hardware:
   a. Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   b. Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
2. Network Control Devices and System Software:
   a. Include technical data for operating system software, service maintenance agreement and device/point count license details.
   b. Provide legally licensed copies of all software tools, configuration tools, management tools, and utilities used during system installation and commissioning.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
4. Cabling: Technical data sheets for all cables.

D. Shop Drawings:

1. Include AISD Project Number on Cover Page.
2. Include specification section and revision on Cover Page.
3. Single-line schematic diagram, top-level subsystem, depicting the network architecture. The top-level subsystem shall illustrate the network media, channel transceiver types, subsystems, network interfaces, Human Machine Interfaces (HMI), repeaters, and terminators if utilized.
4. Floor plan diagrams of the building shall indicate unit and unit controller locations, room numbers or area names and space sensor locations and a diagram of how the BACnet Network wiring is routed from the Building Controller to all of the BACnet controllers.
5. System diagrams for each system and subsystem, including power supply through starters and motors; motor starting and interlock wiring; pushbuttons; all control wiring; interior electrical circuits of control instruments with terminal designations; control motors; colors of wires; wire tags and tag numbers, location of router, controllers, instruments and remote elements; horsepower of motors; normal position of valves, dampers, and relays. A detailed description of the operation of the control system, including control device designation, shall accompany the drawings. The drawings shall include a floor plan and riser diagram of the school indicating unit locations, sensor locations, areas served by each piece of equipment and BACnet Network and Sub-network wiring details with routing of all communication cables.
6. Bill of materials of equipment indicating quantity, manufacturer, and model number.
7. Details of control panel faces, including controls, instruments, and labeling.
8. Schedule of dampers including size, leakage, and flow characteristics.

9. Schedule of valves including flow characteristics.

10. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

11. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram. In the event the sequences proposed by Engineer are unclear, incomplete, or known to be non-compliant with Owner's requirements, Contractor shall issue a Request For Information (RFI) document prior to preparing submittals.
    d. Points list: Provide a complete list of all input and output points, alarms, setpoints and schedules that will be transmitted to and from the Web Server. This point list shall include points to be obtained from BACnet Controllers provided by equipment manufacturers.

E. Preliminary Submittal (Shop Drawings and Product Data)

1. Prepare a Preliminary Submittal for review by Owner, Engineer, and Commissioning Authority.
2. Make arrangements with General and Mechanical Contractors to transmit Preliminary Submittal electronically to all recipients simultaneously, with no paper copy to follow.
3. Shop Drawings and Product Data shall be submitted at the same time but as separate files.
4. Request a Preliminary Submittal Review meeting with General Contractor, Mechanical Contractor, Owner, Engineer, and Commissioning Authority no less than six (6) days after transmittal. This time is required for review by all parties.
5. Contractor shall lead the Preliminary Submittal Review Meeting to address at least the following:
    a. Owner, Engineer, and Commissioning Authority comments;
    b. Resolution to any pending RFI's related to control work;
    c. Final coordination of any controls provided by equipment manufacturers (in which case manufacturers should be asked to attend meeting as well)
    d. Review Submittal Checklist
    e. Timeline for final submittal.

F. Final Submittal (Shop Drawings and Product Data)

1. Prepare Final Submittal after addressing all issues discussed during Preliminary Submittal Review Meeting.
2. Allow six (6) days for review by Owner, Engineer and Commissioning Authority.
3. Do not proceed with installation prior to receiving notification of submittal approval.

1.6 OPERATION AND MAINTENANCE DATA

A. At the time of Functional Testing, update submittal data to reflect condition of systems as installed and programmed.

B. Make any final revisions made during Functional Testing with Owner and Commissioning Authority.

C. Submit ALL requirements listed under Paragraph 1.6 Submittals, as part of the Operation and Maintenance Manual. Include warranty start date.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Refer to Paragraph 1.5.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Installation in accordance with all codes and local ordinances. Refer to Part 3 of this specification for additional installation requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

A. Prior to preparing submittals, coordinate location of control devices and routing of wiring with plans and room and equipment details. For retrofit applications, conduct a detailed inspection of the site and equipment to receive controls in order to identify optimal locations for devices, mounting of controllers, and routing of wiring.

B. It is the intent of this specification that the Section 230926 Contractor shall be responsible for all power and control wiring and raceways associated with the turnkey operational installation of the DDC system. Prior to submittals, coordinate with any additional power requirements that require the involvement of the Division 26 Contractor.

C. Coordinate with other Division 23 Contractors and equipment suppliers for control of mechanical equipment. It is the intent of this specification that the Section 230926 Contractor shall assume responsibility for a turnkey fully operational control system that includes interfacing with controls integral to equipment –whether via conventional electro-mechanical control or BACnet interfaces.

D. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 26 Section "Motor-Control Centers" and “Variable Frequency Controllers” to achieve compatibility with motor starters and annunciation devices.

1.10 WARRANTY

A. The entire BACnet network controls system including wiring, controllers, controlling devices, sensing devices, integral components, service and labor will be warranted for one (1) year from date of system acceptance date unless the manufactures warranty extends beyond the one (1) year warranty. The warranty will then be as indicated by the manufacture of the product.

B. System acceptance date starts upon successful completion of Functional Testing, as determined by Commissioning Authority.

C. If corrective software and/or hardware modifications are made during the warranty period, the BAS controls contractor shall update all user documentation, user and manufacturer archived CD ROM and software disks.

1.11 TRAINING

A. Provide a minimum of **16 hours** of training to AISD personnel. The number of individuals selected for training shall be at the sole discretion of AISD.

B. Training shall cover all aspects of the specified controls system from system overview and operation to basic trouble-shooting. Training shall include a mix of classroom and actual hands on instruction to include but not limited to training during commissioning of BACnet nodes on site and application specific at the BAS system contractor's local office. Training shall include a minimum of eight (8) hours of classroom and eight (8) hours of field training on the newly installed control system. At AISD's discretion, the training may be mixed to allow for more or less time in the classroom or field training areas.

C. The BAS System Contractor shall create an agenda for the training class and submit it for approval by AISD Energy Management Department before training classes are scheduled.

D. Provide all training manuals, materials, and operator and maintenance manuals as required.

1.12 CODES AND STANDARDS

A. The completed and operational BAS shall be in compliance with and meet the requirements of all governing bodies, Authorities Having Jurisdiction (AHJ), applicable local or national standards and codes, except where more stringent or detailed requirements are indicated by the Contract Documents, including the requirements set forth in this Specification and the following:

1. ASHRAE 135-2016: BACnet -Building and Air Conditioning Engineers (ASHRAE)
2. Underwriters Laboratories UL-916: Energy Management Systems (EMS)
3. NIST IR 6392 Annex B: Profiles of Standard BACnet Devices
4. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for Use in Balanced Digital Multi-Point System.

PART 2 - PRODUCTS

2.1 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, distributed control system using ANSI/ASHRAE Standard 135-2016, BACnet technology communication protocols, in an open, interoperable system. The direct digital control (DDC) system shall consist of BACnet based microprocessor-based controllers, plus instrumentation, control valves, dampers, operators, control devices, interface equipment, network manager, BACnet communication interfaces, and other apparatus required to operate systems and perform functions specified. The DDC system shall be capable of providing total integration of the facility infrastructure systems with user access to all system data via Human Machine Interface (HMI) using a Web Browser such as Internet Explorer™, Mozilla Firefox™ or Google Chrome™ connected to the system network using the LAN or WAN.

2.2 NETWORKS

A. The system architecture shall support the following levels.

1. Master Slave/Token Passing (MS/TP)
2. BACnet IP (B/IP)

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE standard 802.3u
2. Cable; 100 Base-T, UTP-8 wire, Category 5e
3. Minimum throughput; 100 Mbps

2.3 GRAPHICAL USER INTERFACE (GUI) SOFTWARE

A. Graphical User Interface: Provide a software tool that allows for the development and management of the end users' Graphical User Interface (GUI) and as the primary point of access to the BAS for the end user.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, log-off button and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

C. Real Time Displays: The GUI shall at a minimum support the following features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating or assembling objects from a GIF, JPG, PNG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.

3. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
4. Schedule and holiday times shall be adjusted using a graphical calendar.
5. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu.
6. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value.

D. System Configuration: At a minimum the GUI shall permit the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies
2. Add/delete objects to the system
3. Tune control loops through the adjustment of control parameters
4. Enable or disable control strategies
5. Override inputs and outputs (permanent and timed)
6. Generate hard copy records or control strategies on a printer
7. Select point to be trended over a period of time and initiate the recording of values automatically.

E. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of 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. All system documentation and help files shall be in HTML format.

F. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

G. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

H. Alarm Console:

1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
2. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2.4 WEB BROWSER CLIENTS

A. A web browser shall be the primary means of access to the BAS for day to day operation from any PC connected to the LAN and remote via internet without the need for any proprietary software.

B. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Mozilla Firefox™ or Google Chrome™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.

C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

D. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
3. HTML programming shall not be required to display system graphics or data on a Web page.
4. Storage of the graphical screens shall be in the Network Control Unit (NCU), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
6. User shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
    b. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    c. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    d. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    e. View logs and charts.
    f. View and acknowledge alarms.
    g. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
    h. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.5 NETWORK CONTROL UNITS

A. The Network Control Unit (NCU) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NCU.

B. The NCU shall be capable of executing application control programs to provide:

1. Calendar functions
2. Scheduling
3. Trending
4. Alarm monitoring and routing
5. Time synchronization
6. Integration of BACnet controller data
7. Network management functions for all BACnet based devices.

C. The NCU must provide the following hardware features as a minimum:

1. 1000Mhz Processor
2. 1GB DDR-3 SDRAM
3. 4GB Flash Memory
4. Wi-Fi Connectivity IEEE802.11a/b/g/n
5. Two 10/100MB Ethernet Ports
6. Two Isolated RS-485 Ports
7. One USB Type A Connector
8. Real Time Clock
9. Support of up to Four IO/Communication Expansion Modules

D. The NCU shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NCU shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

E. The Network Control Unit will provide all scheduling, alarming, trending, and network management for the all BACnet devices.

F. Provide multiple Network Control Units as necessary. The NCU shall support a minimum of 128 BACnet controllers. In order to maintain peak performance of the network, no more than 110 BACnet controllers may be connected to a single NCU and no more than 64 BACnet controllers per NCU Communication Trunk. In any event, no more than 70% of the available resources of the NCU (as indicated by the resource meter of the programming tools for the NCU) shall be committed. In the event that the available resources are less than 30%, the number of nodes connected to the NCU shall be reduced in order to maintain a 30% or greater buffer of resources within the NCU.

G. The NCU shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 5 simultaneous users.

H. Event Alarm Notification and actions - The NCU shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The NCU shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.

1. Alarm generation shall be selectable for annunciation type and acknowledgement; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The NCU shall be able to route any

alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
a. To Alarm
b. Return to normal
c. To fault

2. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
3. Provide timed (schedule) routing of alarms by class, object, group, or node.
4. Provide alarm generation from binary object "runtime" and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control. Control equipment and network failures shall be treated as alarms and annunciated.
5. Alarms shall be annunciated in any of the following manners as defined by the user, but implemented by this contractor:
   a. Screen message on screen
   b. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
      1) Day of week
      2) Time of day
      3) Recipient
   c. Pagers via paging services that initiate a page on receipt of email message.
   d. Graphic with flashing alarm object(s).
   e. Printed message, routed directly to a dedicated alarm printer.
6. The following shall be recorded by the NCU for each alarm (at a minimum):
   a. Time and date
   b. Equipment (Air handler #, pump, etc)
   c. Acknowledge time, date and user who acknowledged
   d. Number of occurrences since last acknowledgement
7. Alarm actions may be initiated by user defined programmable objects created for that purpose.
8. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
9. A log of all alarms shall be maintained by the NCU and/or a server (if configured in the system) and shall be available for review by the user.
10. Provide a "query" feature to allow review of specific alarms by user defined parameters.
11. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
12. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

I. Acceptable Products:

1. JACE-8000:
   a. Niagara N4 Version 4.2
   b. Open License NiCS (Vendor Neutral, No Vendor Locking)
   c. Embedded Workbench
   d. 40% Minimum Spare Capacity (Devices & Points)
   e. 5-Year SMA (Software Maintenance Agreement)

J. Data Collection and Storage

1. The NCU shall have the ability to collect data for any property of any object and store this data for future use.
2. The data collection shall be performed by log objects, resident in the NCU that shall have, at a minimum, the following configurable properties:
   a. Designating the log as interval or deviation.
   b. For interval logs, the object shall be configured for time of day, day of weeks and the sample collection interval.
   c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
   d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
   e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
3. All log data shall be stored in a relational database in the NCU and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements. All log data shall be available to the user in the following data formats:
   a. HTML
   b. XML
   c. Plain Text
   d. Comma or tab separated value
4. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
5. The NCU shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NCU on the network. Provide the ability to configure the following archiving properties, at a minimum:
   a. Archive when the log has reached its user-defined capacity of data stores
   b. Archive on time of day
   c. Archive on user-defined number of data stores in the log (buffer size)
   d. Provide ability to clear logs once archived
6. Provide and maintain an Audit Log that tracks all activities performed on the NCU. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NCU), to another NCU on the network, or to a server. For each log entry, provide the following data:
   a. Time and date
   b. User ID
   c. Change or activity; i.e. change setpoint, add or delete objects, commands, etc.

K. Database Backup and Storage

1. The NCU as provided shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval. Copies of the current database and, at the most recently saved database shall be stored in the NCU. The age of the most recently saved database is dependent on the user-defined database save interval. The NCU database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2. Provide all tools necessary for the development, maintenance, expansion and use of the BAS described within these specifications. All software tools shall be compatible with the network management tool (workbench) that is provided as part of this project. For the purpose of this specification software tools shall be divided into the following categories and meet these specified requirements.

L. NCU Programming Wizards for LCU/TCU Controllers

1. Provide Wizards or objects that facilitate the programming and configuration of the local Control Unit (LCU) and terminal Control Unit (TCU) Controllers sequence of operation through a menu driven wizard. All software tools (including Wizards) shall be compatible with the network management tool (workbench) that is provided as part of this project. The programming and configuration tools shall perform the following functions:
   a. LCU Controllers programming shall be accomplished by Graphical programming language (GPL) where objects are used to define different portions of the control sequence. All control sequences programmed into the controller shall be stored in non-volatile memory. Systems that only allow selection of sequences from a library or table are not acceptable. All code must be exportable to a library for future use.
   b. TCU Controllers – Provide for the programming of the required sequence of operation through an intuitive menu driven selection process. The configuration tools menu shall define items such as I/O configurations, set point, delays, PID loops, optimum start stops, and network variables settings. The configuration tool must indicate the device status and allows system override. Or, provide for the programming of the required sequence of operation through Graphical programming language (GPL) where objects are used to define different portions of the control sequence. All control sequences programmed into the controller shall be stored in non-volatile memory. Systems that only allow selection of sequences from a library or table are not acceptable. All code must be exportable to a library for future use.

M. NCU Network Management Software Tools

1. Provide a complete set of Network Management tools that provides for the development and management of BACnet networks.
2. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
3. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
4. These tools shall provide the ability to “discover” existing BACnet networks, regardless of what network management tool(s) were used to install the existing network, so that existing BACnet devices and newly added devices are part of a single network management database.
5. The network management database shall be resident in the NCU and with proper authorization, shall allow access to the network management database. Systems employing network management databases that are not resident in the NCU, shall not be accepted.
6. System shall allow access to all of the Network Management tool functions including controller programming from a Web Browser.

N. NCU Programming Software

1. Provide programming software for the Network Control Unit that allows for the development of the NCU control logic, point management, global properties such as alarm, trend and scheduling.
2. All library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
3. Programming Methods – Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
    a. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
    b. The software shall provide the ability to view the logic in an off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
    c. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
    d. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

O. NCU Object Library

1. A standard library of software objects that represent functions and applications for the development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.

2.6 LOCAL CONTROL UNITS, TERMINAL CONTROL UNITS, INTEGRATED SPACE SENSORS

A. General

1. All controllers provided as part of this system and used for indoor applications shall operate under ambient environmental conditions of 32 degF (0 degC) to 122 degF (50 degC) dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.
2. All controllers provided as part of this system and used for outdoor applications shall operate under ambient environmental conditions of -40 degF (-40 degC) to 158 degF (70 degC) dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

B. System Design

1. Local Control Units (LCU) shall be utilized for primary mechanical and electrical systems such as Air handling equipment, Make-up Air Unit, Boiler System Control, and Chiller System Control type of applications.
2. Terminal Control Units (TCU) shall be utilized for terminal equipment, such as Variable Air Volume, Fan Coil, Heat Pump, Roof Top applications.
3. Each LCU and TCU controller shall have a minimum of 10% spare capacity of each point type for future points. As a minimum, each controller shall have one spare of each point type available on the controller.
4. The LCU and TCU controller programming or configuration tools shall be fully accessible through the Operator Workstation and Web Browser Client through the use of Wizards. Provide Wizards or objects as specified in NCU paragraph that facilitate the programming and configuration of the LCU and TCU through a menu driven wizard.

C. Controller Local Area Network (BAS sub LAN)

1. Provide a network of stand-alone, distributed direct digital controller that operate on ANSI/ASHRAE Standard 135-2016 BACnet communication protocol.
2. Provide BAS Controllers that utilize BACnet technology and are BTL certified. Controllers using proprietary protocols are unacceptable.
3. The design of the BAS sub-LAN shall network Local Control Unit (LCU) and Terminal Control Unit (TCU) to a Network Control Unit (NCU).
4. This level of communication shall support a family of application specific controllers and shall communicate bi-directionally with the network through DDC Controllers for transmission of global data.
5. Terminal Control Unit (TCU) shall be arranged on the BAS sub-LAN's in a functional relationship manner with Local Control Unit (LCU). Ensure that a Variable Air Volume (VAV) Terminal Control Unit (TCU) is logically on the same LAN or segment as the Local Control Unit (LCU) that is controlling its corresponding Air Handling Unit (AHU).

D. Local Control Units (LCU)

1. The Local Control Units (LCU) shall be 32 bits microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the project point list.
2. Each LCU shall have sufficient memory, to support its own operating system and databases, including:
   a. Control processes

b. Energy management applications
c. Alarm management applications
d. Historical/trend data for points specified
e. Maintenance support applications
f. Custom processes
g. Manual override monitoring

3. Each LCU shall support:
   a. Analog inputs of 4-20 mA, 0-10 Vdc, 10,000 ohm thermistor or 1000 ohm RTD.
   b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
   c. Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:
      1) Digital outputs (contact closure for motor starters up to size 4)
      2) Analog outputs of 4-20 mA or 0-10 VDC
   d. The LCU analog or universal input shall use a 16 bit A/D converter.
   e. The LCU analog or universal output shall use a 10 bit D/A converter.
   f. Each output shall have supervised manual override switch and a potentiometer or integrated LCD operator interface (preferred).
   g. Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. As a minimum, provide one of each type of point available on the controller.
   h. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
   i. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the NCU controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All programmed PID gains and biases shall be available for adjustment via the NCU field-adjustable by the user via terminals as specified herein.
   j. The LCU shall provide local status indication for each output for constant, up-to-date verification of all point conditions via dedicated LEDs or built-in LCD operator interface without the need for an operator handheld device.
   k. The LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
   l. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the NCU Controller. Direct connection to LCU controller for reloading controller software is not acceptable.
   m. Multiplexer boards that convert an analog input into several digital inputs such as the DUIC-5P board are not permitted and shall not be used without explicit authorization from the AISD Energy Management Department.

E. LCU Programming Software

1. Provide programing software for the Local Control Unit (LCU) that allows for the development of the LCU control logic and point management.
2. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
3. Programming Methods –Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.
    a. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
    b. The software shall provide the ability to view the logic with value being inputted/outputted of the graphical blocks (debug mode).
    c. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.
4. Provide function to compare and calculate from multiple values from networked controllers (NCU, TCU and/or LCU). As a minimum, the function shall calculate and compare the values and return the average, sum, highest, lowest, 3 highest and 3 lowest values.

F. Terminal Control Units (TCU)

1. Provide Terminal Control Units (TCU) for control of each piece of terminal equipment.
2. The Terminal Control Units (TCU) shall be 32 bit microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the project point list.
3. Each TCU shall have sufficient memory, to support its own operating system and databases, including:
    a. Control processes
    b. Maintenance support applications
    c. Custom processes
    d. Manual override monitoring

4. Each TCU shall support:
   a. Analog inputs of 4-20 mA, 0-10 Vdc, 10,000 ohm thermistor or 1000 ohm RTD
   b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
   c. Each TCU shall be capable of providing the following control outputs without the addition of equipment:
      1) Digital outputs (contact closure for motor starters up to size 4)
      2) Analog outputs of 4-20 mA or 0-10 VDC
5. The TCU analog or universal input shall use a 16 bit A/D converter.
6. The TCU analog or universal output shall use a 10 bit D/A converter.
7. Controllers shall include all point inputs and outputs necessary to perform the specific control sequences. As a minimum, 25% of the point outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators.
8. Each TCU controller performing space temperature control shall be provided with a matching room temperature sensor.
9. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the NCU controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All programmed PID gains and biases shall be available for adjustment via the NCU field-adjustable by the user via terminals as specified herein.
10. Provide each TCU with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
11. VAV Terminal Control Units:
    a. The VAV box TCU controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC (±15%), allowing for power source fluctuations and voltage drops. The BAS contractor shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32 degF to 122 degF (0 degC to 50 degC) and 5% to 90% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
    b. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall include a built-in differential pressure transducer that shall connect to the VAV terminal unit manufacturer's standard differential pressure sensor to measure the average and amplify differential pressure in the duct. The controller shall convert this value to actual air flow. Single point differential pressure sensing device is not acceptable. The VAV TCU differential pressure transducer shall have a measurement range of 0 to 1 in. W.C. (0 to 250 Pa) and measurement accuracy

of "5% at 0.1 to 1 in. W.C. (25 to 250 Pa) and a minimum resolution of 0.0001 in. W.C. (0.025 Pa), insuring primary air flow conditions shall be controlled and maintained to within "5% of setpoint at the specified minimum and maximum air flow parameters. The VAV TCU differential pressure transducer shall have a zero value air flow measurement repeatability of 0.001 in. W.C. (0.25 Pa), VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable. The BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.

c. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall include provision for air flow balancing using a local air flow balancing interface. A portable air flow balancing interface or an Intelligent Space Sensor (ISS) capable of balancing air flow is acceptable. The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.

d. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall also provide a web browser based air flow balancing tool. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, close all VAV dampers.

e. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within "1.5 degF (0.9 degC) of setpoint at the room sensor location. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements. This algorithm shall function to signal the respective DDC controller to perform the required discharge temperature reset in order to maintain space temperature setpoint.

f. It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.

12. TCU Thermostat

a. Provide Terminal Control Unit (TCU) Thermostat controllers designed with unique functions and featues particular to a specific type of mechanical equipment or applications that may be less common and or standarizied in its use and application.

b. TCU Thermostat – A self-contained controller with a built-in user interface that is intended for installation in the occupied space of the building. The TCU Thermostat shall have the following features:

1) The FCU Thermostat shall be a microprocessor-based fully-programmable controller with all of its control logic, inputs and outputs, network communication and user interface provided within the manufacturer provided enclosure specific to the application. The enclosure shall be aesthetically appealing with a modern design that will fit in with the architecture of the building. A sample of the TCU Thermostat shall be provided as part of the submittal process.

2) The TCU Thermostat shall be programmed through the user interface contained within the controller and through a software based configuration tool.

3) The user interface display shall be provided with 3 levels of password protection: Level 1 – Lockout with view only and time adjustment; Level 2 - schedule override and mode settings; Level 3 – full access to all parameters. Where required in the sequence of operation provide for within Level 2 access the ability to change the units of measure displayed for temperature from Fahrenheit to Celsius. The display shall be back lighted for easy viewing.
4) If required within the sequence of operation, provide for a control schedule and time clock within the TCU Thermostat. The control schedule shall provide for a separate schedule for each day of the week with 4 events per day. The real time clock will have a six hour power reserve time.
5) The TCU Thermostat shall utilize a PI (proportional and integral) control algorithm. Upon power failure, all programmed schedules and parameters must be retained in non-volatile flash memory.
6) Each TCU Thermostat shall be capable of providing the following control inputs and outputs without the addition of equipment:
   a) One (1) on-board thermistor
   b) Four (4) universal inputs (0-10VDC, thermistor, dry-contact)
   c) Five (5) universal outputs (0-10VDC or dry-contact N.O.)

13. Multiplexer boards that convert an analog input into several digital inputs such as the DUIC-5P board are not permitted and shall not be used without explicit authorization from the AISD Energy Management Department.

G. TCU Programming Software

1. Provide programming software for the Terminal Control Unit (TCU) that allows for the development of the TCU control logic and point management.
2. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
3. Programming Methods - Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.
4. Configuration of each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

5. The software shall provide the ability to view the logic with value being inputted/outputted of the graphical blocks (debug mode).
6. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.
7. Provides function to compare and calculate from multiple values from networked controllers (NCU, TCU and/or LCU). As a minimum, the function shall calculate and compared the values and return the average, sum, highest and lowest values.

H. TCU Configuration Software

1. Configuration of the TCU controller shall be done through the configuration tool using fill-in the blank fields, list boxes, and selection buttons.
2. The configuration tool menu shall define items such as I/O configurations, set point, delays, PID loops, optimum start stops, and network variables/object settings. The configuration tool shall indicate the device status and allows system override.
3. The Configurable Controller shall allow the use of its spare I/O as dumb I/O to be shared over the network to other Controllers such as Programmable Controllers, where a sequence of operation can be applied to the I/O. Such applications shall include but not be limited to exhaust fan control, heaters, lighting control, etc.

I. Acceptable Manufacturers/Products

1. To be determined via RFQ process.

2.7 ELECTRONIC INPUT/OUTPUT DEVICES

A. Sensors and Transmitters

1. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, as required to achieve the specified accuracy as specified herein.
2. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
3. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearity of the sensor and bridge and provide a true linear output signal.
4. Temperature sensors shall be of the resistance type and shall be either three-wire 100 ohm platinum RTD, or two-wire 1000 ohm platinum RTD.
5. Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the Control Unit (CU) operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical expressions. Thermistors shall be of the negative thermistor coefficient (NTC) type with a minimum of 100-Ohm/^{o}F resistance change versus temperature to insure good resolution and accuracy. Veris or approved equal. AISD prefers 10K Type II Thermistors.

6. Combination Sensors or "Combo Sensors" such as Temperature and Humidity or CO2 and Humidity are not permitted and shall not be used without prior authorization from AISD Energy Management Department.
7. The following point type accuracies are required and include errors associated with the sensor, lead wire and A to D conversion.

Sensor Type	Range	Min. Accuracy
Duct/AHU Temperature	40 – 130°F	± 0.5 Degree F
Room Temperature	50 – 85°F	± 0.5 Degree F
Outside Air Temperature	-20 – 120°F	± 0.5 Degree F
Chilled Water Temperature	32 – 80°F	± 0.5 Degree F
Hot Water Temperature	80 – 220°F	± 0.5 Degree F
Humidity	0 – 100%	± 3% RH
Duct Static Pressure	0 – 3" w.c.	± 1% full scale per 50°F
Space Static Pressure	- 0.25" – 0.25" w.c.	± 1% full scale per 50°F
Current Sensor	Sized for application	± 1% full scale
Power (kWh)	Sized for application	± 2% full scale (at 1.0 PF)
Air Flow	700 – 4,000fpm	± 2% full scale
Water Flow	Sized for application	± 4% full scale
CO_2 Sensors	0 – 2,000 PPM	± 3% full scale

8. Sensors shall not drift more than 1% of full scale per year.
9. Sensors used in British Thermal Unit (BTU) or process calculations shall be accurate to ±0.10°F over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Institute of Standards and Technology (NIST).
10. Thermowells
    a. When thermowells are required, the sensor and well shall be supplied as a complete assembly.
    b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
    c. Thermowells and sensors shall be mounted in a threadlet or ½" NPT saddle and allow easy access to the sensor for repair or replacement.
    d. Thermowells shall be constructed of the following materials:
        1) Chilled and Hot Water; 316 stainless steel
        2) Condenser Water and Steam; 316 stainless steel
        3) Brine (salt solutions); marine grade stainless steel
        4) Heat transfer grease shall be used on all thermowell applications.
11. Space Temperature Sensors
    a. Each room sensor shall include the following options:
        1) Style: Delta style.
        2) Setpoint Adjustment: The setpoint adjustment slider shall allow for modification of the temperature by the occupant. Each Setpoint Slider shall be adjustable for allowable range from the Graphic User Interface. Default [+/-3F].
        3) Setpoint Adjustment Slider Graduation: "Cool/Warm"
        4) Setpoint Adjust Slider Acting: Direct Acting
        5) Temperature Indicator: Do Not Provide.
        6) Override Switch: Required. In parallel with sensor.

7) Foam-backing: Provide for sensors mounted on exterior walls, CMU walls, structure beams or if sensor reading is being affected by air draft in wall.

12. Outside Air Sensors
    a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall be provided with a solar shield.
    b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
    c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

13. Duct Type Sensors
    a. Duct mount sensors shall mount using a handy box through a hole in the duct and be position do as to be easily accessible for repair or replacement. A neoprene grommet (seal-tight fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
    b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Sensor probes shall be constructed using 304-rated stainless steel.
    c. Duct sensor shall be of the appropriate length and mounted in a location on the duct to obtain the best representation of the actual air temperature.
    d. For outdoor air duct applications, use a weatherproof box with weatherproof cover and gasket.
    e. Sensor handy box shall not be used as a pull-box. Installation shall allow the replacement of sensor without the need for disconnecting/removing additional wiring or conduit.

14. Averaging Duct Type Sensors
    a. Provide capillary supports at the sides of the duct to support the sensing string. Support the middle of the span to prevent flopping of the capillary tube as required. No metal-to-metal contact shall be allowed.
    b. Where the capillary enters the equipment, it shall be protected from sharp edges using a poly tube sleeve.

15. Relative Humidity Sensors/Transmitter
    a. The sensor shall be a solid state, resistance type relative humidity sensor of the bulk polymer design. The sensor element shall be washable and resist surface contaminations.
    b. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10 VDC linear proportional output.
    c. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
        1) Room Type Sensor ±3% RH
        2) Duct Type Sensor ±3% RH
    d. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with seal-tight fittings and stainless steel bushings.
    e. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be pre-calibrated from factory.
    f. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.

16. Differential Pressure Transmitters and Accessories
    a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
    b. Pressure transmitters shall provide the option to transmit a 0-5 VDC, 0-10 VDC, or 4-20 mA output signals.
    c. Pressure transmitters shall be equipped with a LED display indicating the transmitter output signal.
    d. Differential pressure transmitters used for pressure or flow measurement shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (5 valve manifolds).
    e. Provide, at a minimum, a NEMA-1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
    f. Duct sensing pressure applications shall utilize a static pressure traverse probes.

17. Low Air Pressure Applications
    a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
        1) Span: No greater than two times the design space differential pressure
        2) Accuracy: ± 0.5% of full scale
        3) Dead Band: Less than 0.3% of output
        4) Repeatability: Within 0.2% of output
        5) Linearity: ± 0.2% of span
        6) Response: Less than one second for full span input
        7) Temperature Stability: Less than 0.01% output shift per degree change
    b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
    c. Measuring of outside air pressure shall be accomplished by using a pressure pickup probe suitable for outdoor pressure sampling that stabilizes and reduces fluctuations from wind gusts.
    d. Measuring of indoor space pressure shall be accomplished by using a static pressure pickup probe either wall or ceiling mounted.

18. Medium to High Air Pressure Applications
    a. The pressure transmitter shall be similar to the low air pressure transmitter. Provide differential pressure transmitters, which meet the following performance requirements:
        1) Zero & Span: (% full scale/degree): 0.041% including linearity, hysteresis and repeatability
        2) Accuracy: 1% full scale (best straight line)
        3) Static Pressure Effect: 0.5% full scale
        4) Thermal Effects: <±0.03% full scale/degree

19. Low Differential, Water Pressure Applications
    a. The differential pressure transmitter shall be of industrial grade and transmit a linear output signal in response to variation of differential pressure or water pressure sensing points.
    b. The differential pressure transmitter shall meet the following performance specifications:
        1) Die-cast NEMA-4 Enclosure with readout LCD display

2) Suitable input differential pressure range
3) Dual sensor design
4) Microprocessor profiled with built-in noise rejection
5) 0-10VDC, 0-5VDC or 4-20mA output
6) Maintain accuracy up to 20 to 1 ratio turndown
7) Reference Accuracy: ±0.2% of full span
8) Push-button auto-zero
9) Provide with bypass/test manifold

c. Differential pressure transmitters with wired remote sensors are not to be used without the prior approval from AISD Energy Management Department.

20. Medium to High Differential Water Pressure Applications
    a. The differential pressure transmitter shall meet the low-pressure transmitter specifications except the following:
        1) Differential pressure range.
        2) Reference Accuracy: ±1% of full span (includes non-linearity, hysteresis, and repeatability)

21. Bypass Valve Assembly Actuators
    a. Electronic actuators shall be direct-coupled type capable of being mounted over the shaft of the damper or valve. They shall be approved by a suitable safety or regulatory agency. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.
    b. Electronic overload protection shall protect actuator motor from damage. If the damper jams, the actuator shall not burn out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
    c. All bypass valves shall provide a position feedback to the control system.
    d. All 120 VAC powered actuators shall be installed with a locking switch (key operated switch, Leviton 1221-2L) as a disconnection means for servicing within reach of the actuator, but not on the actuator. Verify location with Architect, Engineer, and/or Owner prior to install.

22. Intelligent Space Static Pressure Sensors:
    a. Intelligent space static pressure sensors shall meet but not be limited to the following:
        1) Low pressure type differential pressure transmitter
        2) Integrated Neuron Chip controller
        3) TP/FT-10 network transceiver
        4) Integral power supply for transmitter controller and transceiver

B. Valve and Damper Actuators

1. Electronic Valve and Damper Actuators
    a. Electronic actuators shall be direct-coupled type capable of being mounted over the shaft of the damper or valve. They shall be approved by a suitable safety or regulatory agency. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for

VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.

b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burnout. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.

c. All 120 VAC powered actuators shall be installed with a locking switch (key operated switch, Leviton 1221-2L) as a disconnecting means for servicing within reach of the actuator, but not on the actuator. Verify location with Architect, Engineer, and/or Owner prior to install.

2. Control Damper Actuators
   a. Outside air, return air, and exhaust air actuators shall be spring return type for safety functions. Individual battery backup or capacitor return is not acceptable. With approval, a central battery pack system similar to a uninterruptible power system may be used with a battery checking circuit connected to the DDC automation system. Daily verification of battery performance shall be incorporated in the programming.
   b. The control circuit shall be fully modulating using 0–10VDC, 2–10VDC, 4 - 20 mA, or pulse width modulation signals. Accuracy and repeatability shall be within ±1/21 of control signal. A 0–10VDC, 2-10VDC, or 4 - 20 ma signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within ±2.5%.
   c. Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.

3. Miscellaneous Damper Actuators
   a. Outside air combusting and ventilation air intake and exhaust damper actuators shall be 2 position (open/close) spring return, and close if any water piping, coils or other equipment in the space which the damper servers needs to be protected from freezing.
   b. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air and greater than 2.5" total static pressure.

4. Air Terminals
   a. Air terminal actuators shall be fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers requirements.

5. Inlet Vanes Actuators
   a. Inlet vanes and actuators shall not be used for this job. Speed control of the fan motor shall use a variable frequency drive (VFD).

6. Combination Smoke and Fire Damper Actuators
   a. Actuators shall be factory mounted and connected to the damper section and conform to suitable safety or regulatory agency approved specifications.

7. Valve Actuators

a. Actuators shall have a gear release button on all non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Mount actuators so condensation shall not form on actuators and be prevented by a combination of insulation, air gap, or other thermal break.
b. The control circuit shall be fully modulating using 0–10VDC, 2-10VDC, 4 - 20 mA, or pulse width modulation signals. Accuracy and repeatability shall be within 1/21 of control signal. A 0-10, 2-10VDC, or 4-20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.
c. Valve body and actuators shall be equipped fully assembled and tested at the valve factory.
d. All 120 VAC powered actuators shall be installed with a locking switch (key operated switch, Leviton 1221-2L) as a disconnecting means for servicing within reach of the actuator, but not on the actuator. Verify location with Architect, Engineer, and/or Owner prior to install.
e. All actuators shall be provided with means to accept a ½" conduit fitting.

8. Control Valve Actuators (4 inch and larger)
a. The Valve actuator shall consist of a permanent split capacitor, reversible type electric motor that drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance, and show output shaft and valve position. Unit shall be mounted directly to the valves without brackets and adapters, or readily adapted to suit all other types of quarter-turn valves.
b. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries should be approved by a suitable safety or regulatory agency. Use recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
c. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.
d. The actuator shall have a self-locking gear train that is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with high output torque shall have two adjustable factory calibrated mechanical torque limit single-pole double-throw switch type. The motor shall be fitted with thermal overload protection. The motor rotor shaft shall run in ball bearings at each end of motor.
e. The actuator housing shall be hard anodized aluminum for full environmental protection.
f. The actuator shall be provided with means for manual override.
g. The environmental temperature range of the actuator shall be from –30°C to +60°C (-20°F to +140°F).

h. For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 40ºC.

i. The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15º in each direction of 90º rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as an option.

j. Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cutout protector shall be embedded in the motor windings to limit heat rise to 80ºC in a 40ºC ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.

k. Materials of Construction: The electric actuator shall have a pressure die-cast, hard-anodized aluminum base and cover. The compound gear shall be made of die-cast, hard-anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.

l. Accessories: Potentiometer for providing continuous feedback of actuator position at the CU (for valves specified position feedback).

m. All 120 VAC powered actuators shall be installed with a locking switch (key operated switch, Leviton 1221-2L) as a disconnecting means for servicing within reach of the actuator, but not on the actuator. Verify location with Architect, Engineer, and/or Owner prior to install.

9. Variable Frequency Drives (VFD)

a. Refer to division 23 and 26 for approved list of VFDs and other requirements.

b. The VFD shall communicate utilizing the BACnet protocol via manufacturer card to communicate and receive data through the DDC system. All VFDs shall have separate conduits for hi-voltage input circuits, hi-voltage output circuits and control circuits. In addition to the BACnet communications, each drive shall have two hard-wired points from the BAS system. The two points are as follows:

1) VFD start/stop
2) VFD speed input

c. Remote mounted VFDs with service disconnects between the VFD and the load, shall be wired to the service disconnect early-break auxiliary switch for proper VFD shutdown upon disconnect operation.

C. OTHER ACCESSORIES

1. Electric Low Limit Thermostat (Freeze Stat)

a. Heavy-duty, duct type, fixed differential, vapor-charged sensing element, manual reset, with test/reset button.

b. Sensing element shall be a capillary tube responding to the lowest temperature sensed along any segment of bulb length. Switch shall be rated for 10 amps at full load DPDT (double-pole double-throw).
c. The capillary tube shall be protected from damage at the location that it enters the AHU. Any exposed areas of the capillary tube shall be protected by covering with poly- tubing. Refer to Averaging sensors section above. Provide one 20-feet long bulb thermostat for every 20-sq.ft of coil area.
d. Adjustable Range: 15 to 55 degree F.
e. AISD prefers Johnson Controls A70 Series Low Limit Thermostats.

2. Water Flow Switches
a. Suitable safety or regulatory agency approved device, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Unit shall have two single-pole double-throw switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop at maximum system flow rate.

3. Strap-On Aqua stat
a. Strap-on aqua stats are not to be used without the prior approval from AISD Energy Management Department.

D. FLOW, PRESSURE AND ELECTRICAL MEASURING APPARATUS

1. Traverse Prove Air Flow Measuring Stations
a. Traverse probes shall be a dual manifold, cylindrical, type constructed of 3003 extruded aluminum with an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow and without the physical presence of forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm 20^{o}$ in the approaching air stream.
b. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presences in the airstreams. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
c. Traverse probes shall be accurate to ±2.5% of the measured airflow range and be installed in a duct section that meets manufacturer's installation specifications sheet. Allow adequate distance from elbows, junctions or other disturbances.

2. Shielded Static Pressure Sensor
a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.

b. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow from a radial source.
c. The shielded static sensing devices shall be used for both reference and space pressure sensing.
d. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.
e. All sensors shall be installed according to the manufacturer's installation specifications sheet and in a location that is not subject to frequent air disturbance.

3. Static Pressure Traverse Probe
   a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
   b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
   c. The duct static traverse probe shall be of 304 stainless steel construction and be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure levels without the need for correction factors, and an instrument accuracy of 5% full range.
   d. The probe shall be installed according to the manufacturer's installation specifications sheet and in a location that is not subject to frequent air disturbance.

4. Flow Meters
   a. Electronic Type Flow Meters: (ONICON F-Series Manufacturer or approved equal)
      1) Accuracy of flow meter shall be ±0.5% of reading at calibrated velocity with a pressure drop of less than 1 PSI at 20 ft/s in 1.5" pipe, decreasing in larger pipes and lower velocities.
      2) Electronic sensing method shall be electromagnetic.
      3) Insertion-type for renovation projects.
      4) Inline-type for projects involving new hydronic piping or piping reconfiguration.
      5) The standard temperature range shall be 180º F continuous, 200º F peak. High temperature range shall be 280º F continuous, 300º F peak with an operating pressure of 400 PSI maximum.
      6) The flow meter shall be wet-calibrated at the manufacturer's laboratory against primary volumetric standards directly traceable to NIST. Provide certification of calibration with each meter.
      7) Input signal from flow meter to be 0-10VDC or 4-20mA.
      8) Insertion-type meters shall be installed to allow removal of meter removal during system operation.
   b. Venturi Type Flow Meters:
      1) Pressure drop on venturi type flow meters shall not exceed 0.25" WC. Each venturi low and high-pressure taps shall be equipped with nipples, valves, and quick disconnects.

2) Equip each venturi with a metal identification tag indicating the size, location, flow (gpm), and meter reading for the flow specified.
3) Provide (1) dial differential pressure meter of the proper range to determine piping system flow rate. The meter shall become the property of AISD.
4) Venturi meters shall utilize flanged or screwed connections for removal purposes and shall be rated for the system operating pressures.
5) The venturi flow meter shall be factory calibrated to provide a minimum of flow accuracy between actual and factory flow calibration data.

5. Current Transformers
   a. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design. Solid core current transformers shall not be used without the prior approval from the AISD Energy Management Department.
   b. The core and windings shall be completely encased in a suitable safety or regulatory agency approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
   c. The current transformers shall meet the following specifications:
      1) Frequency Limits: 20 to 100 Hz
      2) Insulation: 0.6 KV Class, 10 KV BIL
      3) Accuracy: ± 1% at 5.0 to 25.0 VA accuracy class with U.P.F burden

6. Current Sensing Switches
   a. The split core current sensing switch shall be self-powered with solid-state circuitry. Current sensing switches shall consist of a solid state current sensing circuit, adjustable trip point, solid state switch, single-pole double-throw or double-pole double-throw relay, as required and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device and looped if required to attain the correct sensing value. The current sensing switch shall accept over current up to twice its trip into range.
   b. It shall be reverse voltage protected and have high over current capability.
   c. Frequency Limits: 20 to 100 Hz.
   d. Accuracy: ±0.5% of full scale.
   e. Response Time: 300 milliseconds to 90% of step change.

7. Power Monitoring
   a. Wattnode BACnet or approved equal.
   b. Current transformers rated and as required for proper interfacing to electrical gear scheduled to be monitored.
   c. Provide voltage disconnect switch and CT shorting block equal to ELKOR i-BLOCK or approved equal.
   d. Install in dedicated control panel.

2.8 CONTROL VALVES AND DAMPERS

A. General Control Valve Requirements

1. All automatic control valves shall be linear, fully proportioning, with modulating ball, plug or V-port inner guidelines unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open, normally closed position or fail in

last commanded state in the event of loss of electronic output signal. See drawings and sequence of operation for system requirements.

2. All valves shall be capable of operating per sequence when required by the sequence of operation. All control valves shall be sized by the BAS system contractor and/or the valve manufacturer, and shall be guaranteed to meet the heating and cooling loads as specified. All control valves shall be suitable for the pressure conditions, and shall close against the differential pressures involved. Valve body pressure rating and connection type (screwed or flanged) shall conform to ANSI pressure classifications appropriate for the system working pressures.
3. All valves shall be programmed to be 0% on HMI = 0 signal on DDC controller = Valve Closed to Coil. Likewise, 100% on HMI = 100% Signal (10VDC, 20ma, etc) on DDC controller = Valve Open to Coil. Same holds true for Dampers (Multizone dampers shall be 0% = Full Hot Deck, 100% = Full Cold Deck). Any deviation from this strategy shall require permission from Owner during the 90% Submittal review.

B. Steam Control Valves: AISD has phased out all steam generating equipment.

C. Hot and Cold Water Control Valves

1. Hot and cold water globe type control valves shall be single-seated type, with equal percentage flow characteristics. The valve discs shall be composition type and shall be sized using ISA methods.
2. Pressure drop through the valves shall not exceed 5 PSI when the valve is fully open and under design flow unless otherwise indicated
3. Ball valves shall be equipped with 316 stainless steel trim, Teflon seals and adjustable packing gland nuts. Provide a handle for manual operation during start-up and maintenance.

D. Air Terminal Reheat Valves

1. Reheat valves shall be modulating logarithmic equal percentage type globe or ball valves as detailed in paragraph C above. 2-position control is not acceptable.

E. Two Position Control Valves

1. For open/closed and/or three-way diverting applications, butterfly valves are acceptable and shall be heavy-duty pattern with a body rating comparable to the pipe rating.
2. Provide each butterfly valve with a replaceable lining suitable for temperature and service requirements.
3. Equip each with a butterfly valve with disc and stainless steel stem.
4. Valves used for shut-off or isolation purposes shall be bubble-tight.

F. Automatic Control Dampers

1. Automatic dampers shall give a feedback of position only when noted in contract documents.
2. Automatic dampers shall have multiple blades and sized for the application by the BAS Contractor and/or as indicated on the design drawings.
3. Submit a schedule of damper sizes to the Prime Contractor, with a copy to the Architect/Engineer and AISD within 15 days after being awarded the contract.
4. Dampers used for throttling airflow shall be opposed blade type arranged for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear. Multi-section dampers must be provided

with sufficient interconnecting hardware or jackshaft for unison operation of all blades in the entire assembly.

5. Damper frames and blades shall be constructed of either minimum 16 gauge galvanized steel or 14 gauge aluminum and arranged to facilitate field assembly of several individual sections into a larger damper area and allow secure fastening of damper frame to the surrounding ductwork, collar or fan housing. Maximum blade length in any section shall not be longer than 48 inches. Additional stiffening or bracing shall be provided for any section exceeding 48 inches in height.
6. Damper blades shall not exceed eight (8) inches in width. All blades except for fume hood exhaust systems shall be galvanized sheet steel. Blades shall be suitable for high velocity performance.
7. All damper bearings to be made of nylon. Bushings that turn in the bearing are to be oil impregnated sintered metal. Dampers shall be tight closing, low leakage type with synthetic elastomer seals on the blade edges and on the top, bottom and sides of the frame. Dampers shall not leak in excess of 8 cubic feet per minute per square foot when closing against 4 inches water gauge static pressure.
8. Leakage and flow characteristic charts shall be submitted to the Architect/Engineer for review.

PART 3 - EXECUTION

3.1 GENERAL

A. Do not proceed with work without approved submittals. Any alterations and/or changes to the control sequences shall be submitted to the Engineer for approval for such changes prior to design of the control system and submittal of control shop drawings. AISD Energy Management Department to review and comment on shop drawings before work begins. All work performed prior to submittal approval shall be at contractor's own risk.

B. Provide all hardware, software, programming, materials, labor, licenses, permits and incidentals necessary to provide completely operational digital controls systems. Perform start up and commissioning on each control product, system, and subsystem to provide fully operable systems in accordance with the specified functional performance.

C. Comply with applicable codes and ordinances. If any conflict arises between these specifications and drawings or codes and ordinances, immediately notify the Architect/Engineer and AISD. Do not deviate from the drawings and specifications nor install any work which may be in conflict with codes and ordinances until the conflict is resolved and the solution accepted by the Architect/Engineer and AISD.

D. The BAS System Contractor is responsible for providing a complete and operational system as described in the description of operation, in the points lists summary, and/or the mechanical/electrical drawings for this project. Any item referenced in one part of the system documentation but not listed elsewhere shall be covered under contractors pricing (i.e. damper called out in sequence but not indicated on drawings).

E. The mechanical, electrical, and building automation system drawings show the general arrangement of the respective systems. Follow these drawings, as closely as actual building construction and the work of other trades permit. Provide devices, fittings, and accessories, which may be required but not shown on the drawings or specified herein. Investigate conditions affecting the work and arrange the work accordingly. Provide modifications and accessories as required to meet such conditions.

3.2 COORDINATION OF WORK

A. Examine and compare the BAS specifications and drawings with the specifications and drawings of the other trades and report any discrepancies between them to the Architect/Engineer and AISD. Obtain the Architect/Engineer's written instructions for changes necessary to the BAS work.

B. Install and coordinate the BAS work in cooperation with the other trades installing interrelated work including mechanical, testing adjusting and balancing, and electrical (including fire alarm) during bidding and submittal process. All changes required in the work of the contractor, caused by inadequate coordination and noncompliance with specifications, shall be made at contractor's expense.

C. Where control system will interface with controls provided by equipment manufacturers, ensure that coordination takes place such that all sequences and required control and monitoring points are made available. Documentation stating "work by others" is not acceptable. All work must be clearly coordinated.

D. Carefully check space requirements with other trades to ensure that all material can be installed in the allotted spaces, including above finished suspended ceilings, between coils sections, etc.

E. Install the BAS work to permit removal (without damage to other parts) of parts requiring periodic replacement or maintenance.

F. Renovations/Additions: The BAS contractor shall examine the existing controls system and shall become familiar with all pertinent components and functions of the existing system, including any energy management systems. The contractor shall be responsible for including all work necessary for the following:

1. Existing controls that are to remain in operation after this project shall remain in place and be modified only as required to incorporate new controls.
2. The new controls shall be fully compatible with the existing system.
3. The new controls shall be fully interconnected with the existing system.
4. In shall be the responsibility of the Prime contractor to insure the coordination of proper decommissioning and disconnection/removal of old control system components that will not be reused. Old database and sequences of operation shall be cleaned up, old conduit and wiring removed, old devices and controllers salvaged and returned to the AISD Energy Management Department in a timely manner. Any controllers and/or field devices damaged during the removal process shall be repaired and/or replaced at no cost to AISD.

3.3 WIRING INSTALLATION

A. GENERAL

1. BAS contractor shall be responsible for all control and power wiring associated with the control system including any related 120V electrical work that may require interlocks, circuit breakers, and/or connections at the panel boards spares or spaces.
2. All electrical work shall be performed in accordance with the requirements of Division 26.
3. All wiring shall be run parallel and perpendicular to building lines (no angles) and concealed where possible. All wiring shall be installed in a professional manner and in accordance with the National Electrical Code and local ordinances. Electrical or mechanical inspection sign off does not remove AISD's right to refuse acceptance of the electrical installation for incorrect or noncompliance with NEC and project specifications. Installation must comply with all local control system electrical code requirements.
4. The control contractor shall use a licensed, qualified and bonded electrical contractor for all wiring above 24Volts.
5. Units already having 120 VAC power run by Division 26 for fans, VAV's, electric heat, etc. shall be provided with required 24 VAC power via a step-down transformer and protected with a circuit breaker, whether provided by the BAS system contractor or unit manufacturer.
6. Provide electrical disconnecting means for servicing, for each control panel, digital controller, transformer, power supply, and other devices that are served by 120VAC or higher voltage.
7. Raceways:
   a. Wiring shall be run in EMT conduit in exposed areas and in vertical risers between floors with sleeves and including any new walls or existing walls that

have additional work being performed. EMT conduit fittings shall be steel compression type. All firewall penetrations shall be caulked with approved fire caulking material.

b. Low voltage plenum rated wire may be used without conduit in concealed but accessible areas (i.e. above lay-in ceilings) and shall be installed in a professional and workmanship like manner and secured up as high as possible. All wall penetrations by plenum cable shall use sleeves with bushings to avoid sharp edges.

c. All conduits on roofs, in areas exposed to weather conditions, in mechanical spaces, and located within six (6) feet above floor level shall be of rigid type conduit with watertight fittings. Use of non-threaded fittings on rigid conduit shall be limited and used only when necessary.

d. Underground conduit shall be of the appropriate schedule PVC or coated ridged and back filled per code.

e. Where flexible metal conduit is used, the maximum allowable length shall be 36 inches, and the minimum shall be 18 inches. All flex conduit fittings shall be of the compression type. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18 inches and maximum length of 36 inches shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigidly mounted conduit. Where exposed to the elements or in damp or wet locations, (such as Mechanical rooms) waterproof flexible metal conduit shall be installed at and below 6 feet above floor level. Installation shall be as specified for flexible metal conduit.

f. When in crawl spaces, EMT conduit may be used when kept up high to the structure; otherwise rigid type conduit shall be used. Waterproof flexible metal conduit shall be used in crawl spaces with the above length requirements.

g. Provide a pull string in all conduits for pulling spare wire.

h. No conduit shall be filled to more than 80% of available space.

8. Coordinate with the Mechanical and Electrical Installation Contractors to ensure controls shall be accessible for repair and maintenance.

9. Provide supervised field-wiring for all alarm panel monitoring points, asset protection points (safeties, sump pumps, maintenance alarms) and all points identified to include supervised wiring on the points schedule.

10. Separate Ground: Where recommended by controls manufacturer for the system/application involved, DDC system/components shall employ and maintain a separate, “clean earth” grounding protection. “Mixing” of grounding systems shall be prohibited. (Isolate DDC controls conduits/metal boxes from other raceway systems using isolation bushings and other measures as necessary.)

11. There shall be no power wiring of 120 volts or higher in the same conduit or raceways with communications or low voltage control wiring

12. There shall be no power wiring of 120 volts or higher in the same conduit or raceways with communications or low voltage control wiring.

13. Control wiring shall follow the following coloring conventions:
    a. Orange: BACnet wiring
    b. Yellow: Thermostat wiring (wall mounted temperature sensors)
    c. White: All other field wiring

14. Hardwired Safety Circuit:
    a. Hardwired safety alarm monitoring and shutdown shall be accomplished through the use of a Fan Safety Relay Board Model: RIBMNLB-6/-4/-2 manufactured by Functional Devices, Inc. or approved equal. The number of

circuits/size of board (6, 4 or 2) shall be selected accordingly to accommodate all the specified safety devices plus one spare relay/circuit. Each safety device shall be manual-reset and shall be homerun to the safety relay board via dedicated wiring. Daisy-chaining of devices shall only be permitted when more than one device of the same kind is required to accomplish the specified scope of work (i.e. two freeze-stats to cover the entire area of the cooling coil). Safety relay board shall be installed in the associated controls cabinet. Enclosed version of this safety relay board shall not be used. Each relay on the board shall be clearly labeled identifying the function of the circuit (i.e. Freeze-Stat, High-Static, Smoke-Detector, etc). The first dry-contact of the master relay shall be used to shut down the fan(s) of the associated unit via the Starter or VFD. The second dry-contact shall be used to report the general status of the safety circuit back to the BMS. Individual status monitoring of safeties shall be provided if specified in the scope of work.

b. Units scheduled to receive only one safety device (i.e. float switch), are permitted to be installed without a Fan Safety Relay Board if safety device is not scheduled to be monitored by the BMS for status reporting.

c. Freeze-stat normally-closed contact shall be homerun to control panel to energize a DPDT (Double-Pole, Double-Throw) relay. First contact shall be wired to Fan Safety Relay Board for Fan Shutdown. Second contact shall be wired to cut power to all spring-return actuators.

B. Wiring less than 30 volts:

1. In ceilings of areas where return air plenum is used, plenum rated cable will be allowed unless noted otherwise. Where plenum cable is used, it shall be run parallel with building lines, banded together in bundles, supported without sags or “clothes line” appearance at 5 foot centers or less. Cabling that is not run in a neat fashion shall be removed and reinstalled. Determination of neatness shall be at the discretion of the Owner and Engineer. All plenum rated cabling shall be clearly marked on the outside jacket to indicate “Plenum” service.
2. Exposed, unfinished locations, such as mechanical rooms and below accessible raised flooring: Conductors and cable plenum rated (where local code or officials allow). All plenum rated cables shall be in conduit in unfinished area and mechanical rooms starting 6 feet above finished floor.
3. Concealed, unfinished locations, such as ceiling plenums, ceiling spaces, shafts, crawl spaces, tunnels: Conductors enclosed in raceway and cable enclosed in raceway or plenum-rated cable (where local code or officials allow).

C. Twisted-Pair Communication Media

1. Only use the transceiver manufacturers recommended cable types.
2. Install the network communications segments for device channels using bus topology format. Install the network communications segments for all backbone channels using bus topology format.
3. Provide all network communication cables, terminations to network control devices and network infrastructure components in accordance with the current requirements of the BACnet Wiring Guide.

D. Control Power Wiring

1. BAS system contractor to provide list/location of all control panels requiring 120 VAC power so they may be coordinated with Electrical.

2. The BAS system contractor shall provide final low voltage power supplies and termination of power wiring to network devices and infrastructure components where required.
3. Provide interlock wiring between supply and return fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.
4. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by this division.

E. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, and at a minimum of 18 gauge conductors.
2. Other analog inputs shall use, twisted, shielded, and at a minimum of 18 gauge conductors.
3. Binary control function wiring shall use at a minimum of 18 gauge conductors.
4. Analog output control functions shall be twisted, shielded, and use at a minimum of 18 gauge conductors.
5. Binary input wiring shall be a minimum of 18 gauge conductors.
6. Thermistors shall be equipped with the manufacturers calibrated lead wiring.
7. 120 VAC control wiring shall be minimum of #14 gauge wire, THHN type, in ½" conduit.

F. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with steel compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections. Rigid steel (RGS) with threaded fittings (connections to junction/outlet boxes and cabinets shall be made with threaded HUBS or double lock-nuts). Provide insulated bushings at all RGS conduit terminations where double lock-nuts are used. The use of Hubs are preferred. The use of threadless RGS fittings shall be kept to a minimum and used only when threading of the GRS is impossible.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

G. Relays

1. Relays other than those associated with digital output cards shall be general-purpose, enclosed plug-in type protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required. All relays shall be equipped with an LED pilot light. AISD prefers IDEC relays.

2. Solid State Relays (SSR): Solid state relays are not permitted and shall not be used without prior authorization from AISD Energy Management Department.
3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contractor shall be double-break silver-to-silver type protecting arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

3.4 CONTROL PANELS

A. Enclosed cabinet type with hinged door for mounting controllers, relays, power supplies and miscellaneous control and communication devices.

B. Control panels shall be fabricated to match the approved shop drawings submitted by the controls contractor. Fabrication shall be in a neat and workmanlike manner and shall facilitate repair, maintenance, and adjustment of the equipment contained therein.

C. Locate all panels in mechanical or electrical rooms. Submit proposed locations for approval prior to preparing control drawings.

D. Control panels shall be fabricated and laid out to incorporate the following features:

1. Lockable doors. All control panels shall be provided with lockable doors using a cylinder AH2 lock kit.
2. Hinged door shall swing left.
3. Identification of all internally and cover mounted devices. Cover mounted labels shall be engraved labels as specified in this section.
4. Provide one duplex outlet mounted inside the control panel. This receptacle may be served from the control panel 120 VAC power source. Label receptacle with source circuit information.
5. Each control panel shall be provided with a control power disconnect switch located and wired so as to disconnect all control power in the panel. Provide one control power disconnect switch per system served (i.e. two disconnect switches for control panel serving two units).
6. All control panels containing electrical equipment shall be NEMA rated for the location in which they are installed. Cover mounted components, tubing penetration, and conduit penetrations shall be made in a manner consistent with the NEMA rating.
7. All conduits entering the control panel shall be fitted with a plastic insulating bushing to prevent cable damage.
8. Wires and tubes that pass from the panel interior to cover mounted devices shall be provided with a flex loop that is anchored on both sides of the hinge.
9. All internal wiring and tubing shall run inside plastic open-slot wire ducts. Wire duct shall be sized to hold the required number of wires and tubes without crimping the wires or tubing and with sufficient space to allow wiring and tubing to be traced during troubleshooting operation.
10. All control panels shall be provided with removable backplane to allow the panel enclosures to be installed at the job site during rough-in while the panels are fabricated off-site for later installation.
11. Labels serving all input/output wiring shall be installed between the open-slot wire duct and the controller so that labels are visible without removing the covers from the wire ducts. Labels shall be as specified in this section.

12. All wiring inside the panel shall be separated by classification; i.e., Class 1 circuits shall not be run with Class 2 circuits, etc. Segregation shall be maintained inside the panel to the fullest extent possible. Where low voltage wires carrying low level ac and dc signals cross wires containing power and high level ac signals, the wires shall cross at a 90° angle.
13. 120 VAC power wiring shall enter the panel separately as close to the point of connection as possible
14. Provide a wireway above or below the control panel whenever more than six conduits enter the panel. Wireway shall be the width of the panel with a minimum of six inches in height and six inches in depth.

E. Panel Location:

1. Each control panel is to be located for convenient servicing. Top of panel shall be at six foot above finish floor.
2. Mount panels adjacent to associated equipment.

F. Network Control Unit (NCU) Panel:

1. Mount in IDF/MDF room or pre-approved location.
2. Provide one duplex outlet mounted inside the control panel.
3. Locate NCU power adapter inside the control panel.

3.5 TEMPERATURE AND PRESSURE SENSOR INSTALLATION

A. Temperature and pressure sensors shall require no field calibrations, initial calibration and range set at factory. BAS contractor to calibrate the DDC system with the field sensors. Thermistors are not field calibratable, but still must be field calibrated with the DDC system.

B. Temperature and pressure sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.

C. Differential pressure transmitters provided with a LCD readout display shall be mounted on wall at 5-feet AFF and nearby from sampling ports in accessible location.

D. Differential pressure transmitters intended for control of building chilled water or hot water distribution pumps, shall be hardwired to the Local Control Unit (LCU) in direct control of the associated Variable Frequency Drives.

E. Sensors installed on units shall be provided with their own dedicated handy box and under no circumstances a sensor shall be “tucked in” or hidden in a junction-box. Installation shall allow the replacement of a sensor without dismantling other sensors, wiring or conduit.

F. Outdoor installation shall be; of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.

G. Sensors shall be provided with protective enclosure where located on plans in common areas (hallways, library, cafeteria, gymnasium). Enclosure shall be clear plastic and keyed alike. Key type is C254A as in a Honeywell Versa Guard TG510A 1001. All Gymnasium areas shall use a wire basket type of enclosure.

H. Sensors in duct shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and

so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.

I. All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to affect proper flow across the entire area of the well.

3.6 INSTALLATION OF ACTUATORS

A. Where damper motors operate outdoor relief, exhaust and fresh air dampers, pretension damper drive linkage to ensure tight closure.

B. Do not install damper motors on ductwork of less than 0.76 mm thick without first reinforcing it.

C. Where a damper motor is installed on an insulated surface of a duct plenum, mount it on a standoff bracket so as not to interfere with the continuity of the insulation.

D. Locate damper motors so that they are easily accessible for testing and servicing.

E. Damper motors shall be selected for the torque requirements of the damper. Damper operators that are undersized for the application shall be replaced with larger operators, at no extra cost. On retrofit applications, when existing dampers are suspected to be dragging, the next larger torque actuator shall be used.

F. Provide one damper motor and linkage for every 2-m^2 damper section area, or as required to meet the torque requirements of the damper under design airflow conditions (or minimum of one damper motor per damper section). Do not use two motors linked together on one shaft, or by jackshaft.

G. Actuators shall be installed in such manner to avoid damage to actuator due to condensation.

3.7 NETWORK INFRASTRUCTURE INSTALLATION

A. All network infrastructure components and wiring shall be installed prior to control device installation. For twisted pair networks - install, test, and document test results and physical locations of cabling, conduit, and junction boxes on as-built drawings.

B. Install and commission all routers, physical layer repeaters, and terminators prior to control device installations. Test routers, etc with the approved network management tool, document results, and identify physical locations of all routers, repeaters, and terminators on as-built drawings.

C. Install necessary power supplies for infrastructure components and devices prior to device installation. Document the following: power source location indicating panel number and breaker id on the set of as-built drawings, at the source panel, and at each device or infrastructure component.

3.8 CONTROL DEVICE INSTALLATION

A. Coordinate with mechanical and electrical contractors and identify each physical network device location. For retrofit applications physically inspect the site. Document locations on shop drawings and include with submittals provided to architect/engineer and AISD Energy Management department representative.

B. Provide all isolation, interfacing, and wiring to complete the installation of equipment items that have integral control systems such as packaged air conditioners, heating units and boiler firing systems. Coordinate with manufacturers prior to submitting proposals and again prior to preparing submittals. Provide all components and circuits and interdisciplinary coordination required to interface the controls system for all required status monitoring, operational features, and fire management functions. Completely test and adjust all systems.

C. Prior to device installation confirm that wiring for all network media, power supply, and I/O has been completed and is available at each location. Notify architect/engineer and/or owners representative immediately of any discrepancies or missing items

D. Install each network device as physically close as possible to controlled equipment with respect to environmental and electrical noise conditions.

3.9 NETWORK DEVICE PROGRAMMING, GRAPHICAL DISPLAYS, STANDARD SETPOINTS, ALARMING AND TREND LOGGING.

A. All network device programming used to implement control sequences shall be provided to AISD. It shall not be necessary for AISD to further program the system. However, provisions shall be made to allow future modification of the installed control programs.

B. Provide licensed copies of all software tools, programming aids, and connecting cables, used to install, develop and troubleshoot the controls system to AISD.

C. Implement the control sequences for the equipment on this project as prescribed in the construction documents and drawing sequence of operation descriptions.

D. Provide the following Graphic User Interfaces (GUI) as the minimum acceptable but not limited to:

1. Home Page (obtain template from AISD)
2. Time Schedule Page
3. Alarm Console Page
4. Trend Logs Page
5. Summary Page(s)
6. Chilled & Hot Water Call Page (if applicable)
7. Floor Plan(s)
    a. Provide each floor plan with key plans and dynamically highlight which part of the key plan is in current view.
    b. Mark location of space sensors to match final installation.
    c. Provide calibrated space readings (i.e. space temp, CO2, RH, etc)
    d. Provide quick links (buttons) to associated HVAC equipment graphic pages.
8. Dedicated GUI per each equipment being monitored/controlled by the BAS
    a. Provide dedicated override points for all outputs.
    b. Group points as follows:
        1) Setpoints: Bottom left-hand side

2) Status Points: Bottom center (i.e. space temp, effective setpoints, etc)
3) Overrides: Bottom right-hand side
4) Actual Occupancy: Top center.
5) All Other Points: Overlaid around HVAC schematic

E. Provide the following minimum cooling and heating setpoints for equipment scheduled to control to maintain space temperature:

1. Base (Cooling) setpoint
2. Slider Adjust Range [default: -3°F/+3°F]
3. Setpoint Dead-Band
4. Effective Cooling Setpoint
5. Effective Heating Setpoint
6. Base (Cooling) Setpoint + Slider Adjust Value = Effective Cooling Setpoint
7. Effective Cooling Setpoint – Dead-Band = Effective Heating Setpoint
8. Night Setup Setpoint (enable)
9. Night Setback Setpoint (enable)
10. Night Setup/Setback Dead-Band

F. Provide Alarm Extensions to the following points:

1. Freeze-Stat (Change of State Alarm)
2. Condensate Float Switch (Change of State Alarm)
3. Low/High Static Pressure Alarm (Change of State Alarm)
4. Fan Command vs Fan Status (Command Failure Alarm)
5. Compressor Command vs Compressor Status (Command Failure Alarm)

G. Provide Trend Logs to the following points:

1. All temperature sensors (Change of Value; Tolerance 1.0F)
2. All outputs
3. All status points

3.10 LABELS AND IDENTIFICATION

A. All devices relating to the work or systems included herein, including controllers, valves, relays, etc., shall be identified with a unique identification number or name on the submitted control drawings. This identification number or name, along with the service of the device (discharge air temperature, freeze-stat, etc.), shall be permanently affixed to the respective device.

B. All field devices shall be supplied with a label indicating its function and point name. Labels shall be “DYMO”-type electronically printed approximately 2-1/2” x 3/4”. Surface shall be cleaned before installing labels. No handwritten labels shall be accepted.

C. Damper and valve actuators shall be labeled indicating which direction is towards open/bypass position (i.e. CW=BYPASS; CCW=OPEN).

D. Label ceiling grid where sensors installed above ceiling when applicable.

E. BAS Panels shall be supplied with a nameplate indicating the equipment being served (i.e. AHU-1 Cafeteria, CO2 Monitoring, etc.). Nameplates shall be engraved on rigid plastic labels approximately 3” x 1”. “DYMO” tape will not be accepted. Only black phenolic with white lettering will be accepted.

F. All 120 VAC power shall be labeled with source panel and circuit number.

G. All BAS Junction Boxes covers shall be spray-painted green with “BAS” stenciled over.

H. All controls wiring, tubing and cabling both inside and outside of control panels shall be labeled at both ends using BRADY PermaSleeve Black on White Wire Marker Sleeves (do not shrink). The wire designations shall match those on the shop and installation drawings. All markings shall be mechanically produced. No handwritten labels shall be accepted.

I. Communication wiring shall be labeled to specify where is coming from (previous device) and where is going to (next device) at each communication drop (i.e. each controller inside a control panel, each VFD provided with a communication card).

3.11 EQUIPMENT PROTECTION AND CLEANING

A. The BAS system contractor shall provide adequate means for and shall fully protect all finish parts of the materials and equipment against damage during the progress of the work until final acceptance.

B. Equipment and accessories shall be thoroughly cleaned of cement, plaster, and other materials; grease and oil spots shall be removed with cleaning solvent and surfaces carefully wiped.

3.12 AIR BALANCING

A. The BAS system contractor shall assign an individual full time to assist the air balance technician during the air-balancing process to assure full balance compliance.

B. The air balance plug-in shall have the ability to globally override local set point values and command all VAV air terminal devices to fully closed, fully open, minimum, and maximum damper positions.

C. All air balance settings and values shall be documented on the as-built control drawings for future reference.

3.13 SUBSTANTIAL PERFORMANCE TEST PROCEDURES

A. General

1. The work under this section shall undergo a formal Functional Testing Commissioning process as documented in Section 230926c. Contractor shall set aside adequate time for the Commissioning process, including point checkout, sequence verification, and graphics checkout. Contractor shall include adequate time to respond to deficiencies without delaying project completion.
2. Prior to requesting Functional Testing, this Contractor shall have every control point checked end to end to ensure accuracy and integrity of the system.
3. Upon completion of control point end-to-end checkout, Contractor shall submit check-out documentation and DDC O&M Manuals to AISD and Commissioning Authority for review. Refer to Part 1 of this specification for O&M documentation requirements.
4. Upon review and approval of DDC O&M documentation, AISD and Commissioning Authority shall schedule the date for commencement of Functional Testing.
5. Controls Contractor shall make available for the Commissioning process a competent technician who is familiar with the installation and programming of the system.

Contractor's technician shall accompany AISD and Commissioning Authority during Functional Testing.

6. Refer to Section 230926c for detailed description and requirements of the Commissioning process.

B. Documentation

1. Upon successful completion of the Commissioning process, and once all deficiencies identified during Commissioning have been corrected, Contractor shall submit a final As-Built DDC O&M Manual with all programming, control points, network variables, setpoints, and graphics as actually implemented.
2. Provide as-built wiring diagrams showing all device locations, infrastructure component locations, control panels, sensors, actuators, ladder diagrams, for associated hardware interlocks, and sequence of operation descriptions for each subsystem within the network design. Show all interfaces with existing and equipment controls.
3. Provide control panel layout sheets complete with point names, point addresses and wire identification numbers. Attach one copy to each respective panel door.
4. All As-Built (O&M Manuals, etc) documentation, shop drawings, points verification sheets, coordination meeting minutes, etc shall be included in the O&M manuals as well as on a Compact Disc (CD) accompanying the final As-Builts.

C. Software Backups & Platform Access

1. Upon successful completion of the Commissioning process, the Contractor shall provide a Platform & Station Backup of the Network Control Unit along with the Credentials to access the NCU Platform.

3.14 PROJECT ACCEPTANCE

A. Upon receipt and approval of final DDC O&M Controls work shall be considered substantially complete, as recommended by the Commissioning Authority and approved by Owner and Engineer For additional acceptance requirements see Div 230926c.

3.15 POINT LISTS AND SEQUENCES OF OPERATIONS

A. Refer to drawings.

END OF SECTION 230926a

SECTION 230926c

COMMISSIONING OF BUILDING AUTOMATION SYSTEM (TRIDIUM-BACNET)

PART 1 - GENERAL

1.0 SCOPE

This specification is Austin Independent School District's Division 230926c Rev. 7/30/2018 and supplements the Commissioning Requirements in Division-1 with specific requirements from Direct Digital Controls (DDC) specified under Division 23. This specification shall be used in its entirety and shall only be modified by, or with permission from AISD-Energy Management Department.

1.1 RELATED DOCUMENTS

A. Division-1, Section 019113 -Commissioning Requirements, addresses responsibilities and procedures for the commissioning process. All requirements of Division-1 specifications apply to this section.

B. Division-23, Section 230926a -Direct Digital Controls for Local Building Automation Systems (TRIDIUM-BACNET) addresses requirements for design, installation and testing of DDC system using the BACnet protocol for local control of building HVAC systems. All requirements of Section 230926a apply to this section.

1.2 RESPONSIBILITIES

A. Commissioning is the joint responsibility of the Contractor (including subcontractors and vendors) and the Commissioning Authority hired directly by the Owner, the Owner, and the Design Engineer. General assignment of responsibilities during the Commissioning process is specified in Section 019113. All the requirements of Section 019113 apply to this section.

B. (General) Contractor retains responsibility for coordinating participation of Local Building Automation System subcontractors (Section 230926) throughout the commissioning process, and for ensuring participation by other subcontractors and equipment suppliers, vendors and manufacturers as required to conduct activities specified herein.

C. Building Automation Systems subcontractor (Division 23) is responsible for assigning representatives with expertise and authority to act on behalf of the subcontractor to conduct commissioning activities specified. Building Automation Systems subcontractors are also responsible for providing tools, software and equipment required to conduct commissioning activities.

D. Commissioning Authority is responsible for organizing, witnessing and documenting commissioning activities specified.

E. Owner is responsible for assigning personnel with expertise and authority to act on behalf of the Owner as relates to commissioning of Building Automation Systems, and to provide access to facilities, equipment, and servers as required to conduct commissioning tasks.

F. Design Engineer is responsible for developing a design that is in compliance with the Owner's Project Requirements and Design Guidelines and for responding to Commissioning Authority's comments.

Design Engineer is also ultimately responsible for the proper operation of the system as designed, regardless of whether or not he chooses to participate in testing and demonstrations.

1.3 SUMMARY OF WORK

A. DESIGN PHASE (Information Only)

1. Conceptual Design Meeting: Early during Conceptual Design and prior to making firm decisions on the type of HVAC systems and controls to be provided, Design Team shall request a meeting with AISD Service Center personnel and Owner's Commissioning Authority. The main objective of the meeting is to review the Owner's Standard Specifications and Guidelines and ensure design will proceed in accordance.

2. Preliminary Design Submittal: Design Engineer provides complete DDC points list and sequence of operations for all systems at DD design submittal and again at 95% CD design submittal. Sequences and points lists shall be in accordance with Owner's guidelines and standard points lists. Electronic Submittals shall be provided to AISD Service Center personnel and Owner's Commissioning Authority.

3. Design Review Comments: Owner and Commissioning Authority provide comments upon review of DD and 95% CD design submittals. Comments issued in electronic form.

4. Design Review Meeting: A final design review meeting is held upon review of 95% CD's, to verify inclusion of review comments in design. Meeting is attended (at least) by Design Engineer, Owner, and Commissioning Authority. Commissioning Authority provides written documentation of decisions made during meeting.

5. Design Review Follow-up: Commissioning Authority conducts a follow up review of Construction Documents issued for permitting/bids and forwards comments to Owner and Engineer on any outstanding items.

B. SUBMITTAL PHASE

1. Preliminary Submittal: Controls subcontractor (Div-23) provides preliminary DDC submittal in accordance with specifications, with digital copies transmitted to AISD Service Center and Owner's Commissioning Authority (ACR). This submittal shall occur shortly after contract award and prior to approval of equipment submittals so that systems may be properly coordinated. In addition to requirements of Section 230926, Building Automation System submittal shall include at least the following:

a. Detailed written sequences as they will actually be programmed and using the program variable names;

b. Complete point lists including all controlled devices, monitored values, status points, set-points and all variables obtained from BACnet devices including those from equipment provided with BACnet communication cards;

2. Preliminary Submittal Review: Owner and Commissioning Authority issue joint review comments on Preliminary Submittal to Engineer for inclusion with Design Team's review comments to Contractor.

3. Preliminary Submittal Review Meeting: Upon acknowledgement of receipt of Preliminary Submittal review comments, Local Controls subcontractor will request through the Contractor and AISD Project Manager, a review meeting with Owner, Engineer, and Commissioning Authority. Commissioning Authority documents action items resulting from meeting for inclusion in Final Submittal.

4. Final Submittal: Upon addressing comments, Local Controls subcontractor issues Final Submittal for review by Engineer, Owner, and Commissioning Authority.

5. Final Submittal Review Comments: Owner, and Commissioning Authority issue joint comments to Engineer for inclusion with Design Team's final submittal review comments to Contractor.

6. No hardware installation should take place prior to receiving submittals that have been approved by Owner, Engineer and Commissioning Authority.

C. PRE-FUNCTIONAL INSPECTION -Local Building Automation Systems Controls

1. Controls Contractor Request for Pre-Functional Inspection: Upon completion of installation and programming of ALL systems, Controls subcontractor shall issue a written request for Pre-Functional Inspection by Engineer, Owner and Commissioning Authority, certifying that the following work is complete and ready for inspection:

   a. Manufacturer start-up has been conducted for all equipment requiring it - coordinate with Mechanical Contractor;

   b. Piping has been flushed and (preliminary) test and balance completed - coordinate with Mechanical Contractor;

   c. All control and monitoring devices installed, wired and tested;

   d. Point-to-point check to verify correspondence of control points to control devices verified (provide report);

   e. All operational sequences tested;

   f. Control Panel layout sheets complete with point name, point address, and wire identification number (indicating DDC device), with one copy attached to each respective panel door;

   g. All points and devices permanently tagged with point name, address, and panel number;

   h. As-Built Controls Diagrams and Sequence Documentation reflecting systems as programmed and installed, to be used during inspection.

2. Pre-Functional Inspection: Contractor shall set aside a minimum of two days to conduct a joint Pre-Functional Inspection of Local Controls Building Automation System work with Engineer, Owner and Commissioning Authority. Work will include the following:

   a. Physical inspection of installation for compliance with specifications;

   b. Sample testing of sensors and devices for verification of calibration;

   c. Sample point-to-point checkout to verify correspondence of commanded points to controlled devices;

   d. Testing of central plant cooling sequences including plant enable/disable sequences and call for unoccupied operation;

   e. Testing of central plant heating sequences including plant enable/disable and call for unoccupied operation;

   f. Testing of air handler units operating sequences (sampling) including occupied/unoccupied sequences and call for unoccupied operation;

   g. Testing of zone controls (fan-coil, dx-split, vav-boxes) operating sequences (sampling) including occupied/unoccupied sequences and call for unoccupied operation;

3. Pre-Functional Inspection Report: Commissioning Authority prepares a report detailing deficiencies identified during Pre-Functional Inspection and submits to Engineer so he may evaluate and forward to Contractor.

4. Pre-Functional Re-Inspection(s) Request: Upon completion of items on Pre-Functional Inspection Report, Local Controls subcontractor issues a request for Pre-Functional Re-Inspection and the process is repeated.

5. Pre-Functional Acceptance: Upon completion of all items identified during Pre-Functional Inspection, Commissioning Authority issues an official notification of Pre-Functional Acceptance to Engineer so he may forward to Contractor.

6. When deem advantageous to the project, and depending on system configuration, Pre-Functional Inspection and Functional Testing may be combined into a single activity, at CxA's discretion.

D. FUNCTIONAL TESTING

1. Point Check-out Request: Upon completion of controls installation, the Controls Contractor shall submit documentation and issue written notification to Owner, Engineer, and Commissioning Authority stating that the entire system is ready for Point Check-out, including all graphics.

2. Point Check-out & Report: Commissioning Authority shall inspect system via the Web-based Graphic User Interface (GUI) to verify that all specified points are present, that they are reading properly and that they are accessible, commandable and

overridable as specified. Commissioning Authority will issue a point check-out report listing deficiencies to be corrected.

3. Point Check-out Corrections: Controls contractor shall correct deficiencies listed in the Point Check-out Report and issue written notification when system is ready for Functional Testing.

4. Functional Testing: Upon notification by controls contractor that deficiencies in the Point Check-out Report have been corrected, Engineer, Owner, and Commissioning Authority will meet controls contractor at the project site to conduct Functional Testing as described in Part-4 of this specification.

5. Functional Test Report: Upon completion of Functional Testing, Commissioning Authority shall issue a report listing deficiencies to be corrected.

6. Functional Testing Deficiencies Resolution: Controls contractor shall resolve deficiencies in Functional Test Report. Corrections shall be accomplished within a period of no more than 2 weeks. Upon correction of deficiencies, Contractor shall notify Owner and Commissioning Authority when system is ready for Final Functional Testing.

7. Final Functional Test & Report: Upon receiving notification from Contractor, Owner and Commissioning Authority will verify corrections to controls systems. Commissioning Authority will complete a Final Functional Test Report documenting that systems work as per design intent, and/or outlining any recommendations for future improvement.

E. O&M MANUALS AND AS-BUILT DOCUMENTS

1. Requirements for O&M Manuals and As-Built Documentations are included in Section 230926a.

2. Commissioning Authority shall conduct review of O&M's and As-Builts concurrently with Engineer and track documentation.

F. TRAINING

1. Requirements for training of Owner's personnel are included in Section 230926a.
2. Commissioning Authority shall review training material and attend selected training sessions as deemed useful in order to document adequacy.

PART 2 - PRODUCTS -NOT APPLICABLE

PART 3 - EXECUTION -NOT APPLICABLE

PART 4 - FUNCTIONL TESTING PROCEDURES

4.0 GENERAL

A. Seven (7) Day Performance Test: Contractor shall schedule a seven (7) day period to conduct Functional Testing specified herein. Any upset of system operational functionality greater than (2) hours during the seven (7) day test period shall cause the test to be restarted.

B. Prerequisites for Functional Testing: The following must be complete prior to proceeding with Functional Testing

1. Pre-Functional Testing and Acceptance Notice by Commissioning Authority.

2. End to End Point Checkout by Contractor.

3. Point Checkout Report by Commissioning Authority.

4. Time schedules built and in control of time-controlled equipment.

5. Graphics displays installed and fully operational for each unit, system, and subsystem.

C. Trending: Implement the following trends prior to initiating testing.

1. Each space sensors shall be placed on a five (5) minute trend for 24 hours to document accurate temperature control of room or zone. Trends shall be recorded electronically for inclusion in Commissioning Report.

2. Each control loop measured variable, controlled variable and setpoint if calculated shall be place on a one (1) minute continuous trend for at least twenty-four (24) hours to document stability of loop. Trends shall be recorded electronically for inclusion in Commissioning Report.

3. Runtime totalizer shall be set on selected digital outputs.

4. Additional variables will be trended at the request of Owner/Commissioning Authority.

4.1 FUNCTIONAL TESTING

A. Local Network Testing (BACnet)

1. The fire alarm system shall be enabled at the time of testing to ensure correct action of all fire and smoke sequences that interface with controls.

2. Network traffic for each device channel shall be measured for 24 hours utilizing a protocol analyzer tool. Channel analysis shall include bandwidth utilization, and error

statistics. Reconfigure nodes and/or install additional routers as necessary to maintain traffic at a no more than 60% of channel bandwidth capacity. Backbone channels that contain permanent HMI's shall consume no more than 30% of total bandwidth capacity.

3. Each network control device, intelligent router, and network interface shall be tested and health verified using the protocol analyzer diagnostics application. Test results shall include neuron error log statistics, self-test results and device state information.

4. A power failure for the building shall be simulated and system recovery monitored. A protocol analyzer log shall record the network traffic for each channel for a 60-minute period following building power restoration.

5. Disable all sending (upstream) devices and simulate connection failures for receiving devices (downstream) that implement fail-safe configuration settings. Verify that downstream devices play failsafe values in the event that network variable updates are not detected by downstream devices within the minimum receive update intervals.

6. Test results shall be printed, recorded electronically and submitted to Owner, Engineer and Commissioning Authority.

B. Functional Testing of Sequences and Controls

1. Functional Checklists: Functional Testing forms shall be developed by Commissioning Authority for each specific system or subsystem to be tested, identifying all control and monitoring points that must be active.

2. End-to-End Verification: Proper operation/response of controlled points shall be verified from the Web-based Graphic User Interface (GUI) front-end to the actual physical devices in the field, as follows:

   a. Controlled devices shall be commanded to a value at the GUI and its reaction observed in the field.

   b. Status points shall be changed and observed both in the field and at the GUI.

   c. Selected sensors shall be tested for accuracy and proper placement to ensure that sensors are properly assigned to the area served.

   d. Selected points shall be disabled in the field and the proper alarm/response verified at the GUI.

3. Sequence Verifications: Proper operation of programmed sequences shall be verified for each major system type and sampled for multiple identical systems. Sequence verification will include the following as directed by the CxA:

   a. Response to time schedule commands.

   b. Response to changes in setpoints.

c. Responses to changes in field conditions.

d. Response to loss and restoration of power.

e. Response to loss and restoration of communication.

END OF SECTION 230926c