# DIVISION 25 – INTEGRATED AUTOMATION

## SECTION 25 51 00-INTEGRATED AUTOMATION FACILITY CONTROLS

## PART 1: GENERAL

### 1.1 SCOPE OF WORK

A. General Contractor shall furnish and commission a fully integrated building automation system (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as herein specified.

B. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specifically, for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years.

C. General Contractor and the Installing Contractors shall furnish and/or install all equipment and systems specified herein.

### 1.2 DESCRIPTION

A. The control system will consist of a BACnet high-speed, peer-to-peer network of BTL certified controllers and a front end that operates on a BACnet IP (Internet Protocol) Network.

B. An operator workstation shall be available that allows user access. The user shall interface with the network via multi-tasking dynamic color graphics. Each mechanical system, building floor plan, and control device will be depicted by a point-and-click graphic.

C. For Local Area Network installations provide access to the control system via the Texas State University Intranet.

D. The system shall support remote access, setpoint adjustment, schedule changes, calendar changes, point overrides, and graphics screens over the Texas State University WAN, and the Internet via University approved VPN access.

E. The System will provide for future expansion to include monitoring of the lighting control systems.

### 1.3 RELATED SECTIONS

A. Division 1 - General and Special Conditions

B. Division 23 - Mechanical

C. Division 26 - Electrical

D. Division 22 - Plumbing

E. Drawings and general provisions of the contract, including general and Supplementary Conditions and Division 1 specification sections, apply to this section.

## 1.4 QUALITY ASSURANCE

A. The BAS system shall be designed, commissioned, and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Provide 800 number accesses to 24/7/365 support center, staffed with factory-trained personnel to assist in trouble shooting and problem resolution.

B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

C. BAS shall comply with UL 916 PAZX and 864 UDTZ, European Community, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.

D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.

E. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

F. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels and extend new field panels on a previously installed network.

G. Contractor/Manufacturer Qualifications:

1. Reference Section 1.04.A as well as the following.

2. Contractor shall have an established working relationship with the Control System Manufacturer for a minimum of 10 years.

   All products used in this installation shall be new and not scheduled for discontinuation for at least 5 years. Parts must currently be in production under manufacture and shall be applied in standard off the shelf products. This installation shall not be used as a test site for new products unless explicitly approved by Texas State University Technical Services in writing.

3. Spare parts will be available for at least 5 years after completion of the contract.

## 1.5 SUBMITTALS

A. Pre-Construction Submittals:

1. Contractor shall provide supply control drawings and other submittals on all hardware, software, and installation to be provided under this scope. No work may begin on any segment of this project until submittals have been reviewed and approved for conformity with the design intent. This will include all Wiring Diagrams, and all completed programming (not just Engineered Sequence).

2. Physical copies shall be submitted to Facilities, Planning, Design and Construction. Electronic Submittals will be provided to Facilities, Planning, Design and Construction as well as to Technical Services for review and approval.

3. Provide a "Comply/Non-Comply" statement for each section or sub-section of this specification with transmittal of the 25.51.00, 1.7 SUBMITTALS.

4. Refer to A-1 in the Appendix at the end of this document.

B. Post-Construction As-Builts:

1. All As-Builts will be provided on USB Flash Drive or Internet Download to Technical Services, as well as to Facilities Planning, Design, and Construction, where Facilities, Planning, Design, and Construction will be required to transmit to Archive.

2. Terminal Equipment Network/Power Trunk Connection Layouts will be supplied for all Networked devices. This will be provided directly to Technical Services, via digital format, along with All As-Builts as a floor layout with the actual Terminal Equipment locations and how the Floor Level Network is run to each unit, labeling what Controller/Floor Level

   Network or MSTP Trunk it belongs to as well as power trunk if applicable.

## 1.6 WARRANTY

A. Provide all services, materials, and equipment necessary for the successful operation of the entire BAS system for a period of one year after system acceptance. Any equipment shown to be defective during the warranty period shall be adjusted, repaired, or replaced at no additional charge to the owner.

B. The adjustments, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

## 1.7 CODES AND STANDARDS

A. National Electric Code (NEC)

B. International Building Code (IBC)

C. Uniform Mechanical Code (UMC)

D. ASHRAE 135-(Current Revision)

E. ASHRAE 90.1 (Current Revision accepted by Texas Energy Code)

F. ASHRAE 90.2 (Current Revision accepted by Texas Energy Code)

G. FCC Regulation, Part 15- Governing Frequency Electromagnetic Interference

H. Underwriters Laboratories UL916

**1.8 SYSTEM PERFORMANCE**

A. The system will conform to the following standards:

1. Graphic Display. The system shall display a graphic with dynamic points/objects with all current data within 10 seconds.

2. Graphic Refresh. The system shall update a graphic with dynamic points/objects with all current data within 8 seconds

3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 2 seconds. Analog objects should start to adjust within 2 seconds

4. Object Scan. All changes of state and change of analog values will be transmitted over the high-speed Ethernet network such that any data used or displayed at a controller or workstation will have been current within the previous 8 seconds

5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds

6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 1 second. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control

7. Performance. Programmable controllers shall be able to execute DDC PID control loops at a frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency

8. Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other

9. Reporting Accuracy. The system shall report all values with an end-to- end accuracy as listed or better than those listed in Table 1.

10. Stability of Control. Control loops shall maintain measured variable at setpoint within the tolerances listed in Table 2.

B. Table 1: Reporting Accuracy

| Measured Variable | Reported Accuracy |
|---|---|
| Space Temperature | ±0.5ºC [±1ºF] |
| Ducted Air | ±0.5ºC [±1ºF |
| Outside Air | ±1.0ºC [±2ºF] |
| Dew Point | ±1.5ºC [±3ºF] |
| Water Temperature | ±0.5ºC [±1ºF] |
| Delta-T | ±0.15ºC[±0.25ºF] |
| Relative Humidity | ±5% RH |
| Water Flow | ±5% of full scale |
| Airflow (terminal) | ±10% of full scale *(see Note 1)* |
| Airflow (measuring stations) | ±5% of full scale |
| Air Pressure (ducts) | ±25 Pa [±0.1 "W.G.] |
| Air Pressure (space) | ±3 Pa [±0.01 "W.G.] |
| Water Pressure | ±2% of full scale*(see Note 2)* |
| Electrical (A, V, W, Power factor) | ± 0.2% Revenue Class Certifiable *(see Note 3)* |
| Carbon Monoxide (CO) | ±5% of reading |
| Carbon Dioxide ($CO_2$) | ±50 ppm |

Note 1: 10%-100% of scale.
Note 2: For both absolute and differential pressure.
Note 3: Not including utility-supplied meters.

C. Table 2: Control Stability and Accuracy

| Controlled Variable | Control Accuracy | Range of Medium |
|---|---|---|
| Air Pressure | ⍰50 Pa [⍰0.2" w.g.]<br>⍰3 Pa [⍰0.01" w.g.] | 0-1.5 kPa [0-6" w.g.]<br>-25 to 25 Pa [-0.1 to 0.1" w.g.] |
| Airflow | ⍰10% of full scale | |
| Temperature | ⍰0.5ºC [⍰1.0ºF] | |
| Humidity | ⍰5% RH | |
| Fluid Pressure | ⍰10 kPa [⍰1.5 psi] | 0-1 kPa [1-150 psi] |
| " " differential | ⍰250 Pa [⍰.20" w.g.] | 0-12.5 kPa [0-50"w.g.] |

# PART 2: PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

A. Siemens (BACnet IP or MS/TP)

B. Delta Controls (BACnet IP or MS/TP)

C. Distech Conrols (BACnet IP or MS/TP) – Approval for Small Projects Only at this time.

D. Other manufacturers may be approved through Technical Services on an as needed basis, as long as vendor supports Native BACnet, and conforms to IT Security Protocols as required by Texas State University IT Standards.

## 2.2 MATERIAL

A. All products used in this project installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by a Texas State University Representatives in writing. Spare parts shall be available for at least five years after completion of this contract.

B. All DDC Controllers shall be BACnet Test Laboratory (BTL) listed.

## 2.3 NETWORKING COMMUNICATIONS/OPERATOR WORKSTATION INTERFACE

A. The design of the BAS shall be network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels; a campus-wide Ethernet based management level network on TCP/IP protocol, a high-performance peer-to-peer building level network and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data .

B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network with the use of gateways or protocol converters if necessary.

C. All control products provided for this project shall comprise a BACnet internetwork. Communication involving control components (i.e. all types of controllers and Operator Workstations) shall conform to ANSI/ASHRAE Standard 135, BACnet.

D. Each BACnet device shall operate on the BACnet Data Link/Physical layer protocol specified for that device and shall conform to the following instancing scheme. All controls contractors will be required to contact Texas State University Technical Services personnel to obtain confirmation that their Instancing Scheme will be acceptable prior to Submittal approvals.

E. The time clocks in all controllers shall be automatically synchronized daily.

F. Peer-to-Peer Building Level Network:

1. All operator devices shall have the ability to access all point status and application

report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time. Network shall support a minimum communications speed of 115.2 Kbps. No device shall be capable of communicating outside of Building Network, except through BACnet Broadcast Management Devices.

2. The system shall support integration of third-party systems (lighting, PLCs, chiller, boiler) using integration with standard protocols including BACnet, and Modbus. This DDC Controller shall exchange data between the two systems for inter-process control. All exchange points shall have full system functionality as specified herein for hardwired points. LONWorks Communication Protocol will not be authorized for use at any time.

G. Management Level Network

1. The Building Automation System Front End shall simultaneously connect to all Building Networks via BACnet IP.

2. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in an alarm notification at the Workstation.

H. DDC Controller Field Networks, via MSTP, or IP Networks

1. This communication shall support controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data. A minimum speed of 38400 Kbps shall be supported.

I. Building Automation System Front End

1. Building Automation System Interface

a. The BAS shall provide a graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet.

b. A Virtual Server, or Web Based Building Automation Interface will be supplied, as approved by Texas State University IT Department.

2. Web Server:

a. Shall be capable of supporting an unlimited number of clients using a standard Web browser via HTML5 based browser such as:

1). Microsoft Edge

2). Google Chrome

b. 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.

c. The Web Browser Client shall support at a minimum, the following functions:

User log-on identification and password shall be required, via Texas State University Active Directory and LDAP Services.

1). Alarm Management: . Provide a means to display a summary of all active alarms, when they occurred and a means to filter alarms by alarm classification (critical, maintenance, network, HVAC, etc.). Provide an historical alarm and event log and timeline to support analysis of alarm activity, operator activity (like logins and commands) and changes to the system.

d. Storage of the graphical screens shall be in the Server, without requiring any graphics to be stored on the client machine.

e. Real-time values displayed on a Web Page shall update automatically without requiring a manual “refresh” of the Web Page.

f. Users shall have administrator defined access privileges. Depending on the access privileges assigned, the user shall be able to modify common application objects, such as schedules, calendars, and set points in a graphical manner.

g. Operator Workstation located at Texas State University designated location will communicate with the entire control system using the Texas State University existing Wide Area Network. Texas State University shall furnish appropriate static IP addresses for the new system’s BACnet Broadcast Management Devices.

h. Server Hardware will be a Virtual Server provided by Texas State University or must be approved by Texas State University IT Department and Technical Services prior to bid.

i. SYSTEM SOFTWARE

1). Operating System. Furnish a concurrent multitasking operating system. The operating system also shall support the use of other common software applications that operate under Microsoft Windows. Must run current supported version of Windows that has been approved through the Texas State University IT Department.

2). Upon Controls Contract being awarded, the Controls Contractor will be required to contact Texas State University Technical Services to obtain current Texas State University graphics standards and Instance Scheme.

3). All System/Building Graphics will be submitted to Texas State University Technical Services prior to being installed.

4). System Graphics. The operator workstation software shall be a graphical user interface (GUI). The system shall allow display of multiple dynamic and animated graphic screens at once for comparison and monitoring of system

status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic.

5). Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be able to create and modify graphics. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs (ex. Visio or AutoCAD).

6). Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork.

7). Multilingual. Software shall be supported in the following languages English.

*j. System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation:*

1). System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users and is required to be under proper password protection.

2). On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On- line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

3). Security. Each operator shall be required to log on to the system with a username and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to configure security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application. Control System will have the ability to integrate to our LDAP System, as well as integrate to our Multi-Factor Authentication system.

4). System Diagnostics. The system shall automatically monitor the operation of all workstations, network connections, building management panels, and controllers.

5). Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include change-of-value

digital, change-of-value analog, time interval, start time, and stop time. Trend data shall be sampled and stored on the Building Controller panel and be archivable on the hard disk and be retrievable for use in spreadsheets and standard database programs.

6). Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms.

7). Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.

8). Clock Synchronization. The real-time clocks in all building control panels and workstations shall use the BACnet Time Synchronization service. The system also shall be able to automatically synchronize all system clocks daily from any operator-designated device in the system. The system shall automatically adjust for daylight savings and standard time, if applicable.

*k.* Engineering Software Tools.

1). Controller. Must provide software to program every aspect of controller from startup to commissioned operations.

l. REPORT MANAGEMENT

1). The following reporting capability shall be provided at the operator workstation.

2). Reporting:

a). Internal reports built into operator workstation software

b). External reporting via REST API.

3). Internal Reports

a). User definable query reports (support advanced multiple property, multiple object).

b). Reports shall be scheduled for automatic generation by schedule or event.

c). Manual execution to printing/file.

d). Ability to save reports.

e).

f). Report to multiple destinations

i. Email

ii. Print

iii. File (text, csv, xml)

iv. Terminal

## 2.3 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLER

A. Manufacturers must provide PIC Statements prior to bid.

## 2.4 DDC CONTROLLERS

A. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Manual override monitoring

B. Each DDC Controller shall support firmware upgrades without the need to replace hardware.

C. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.

D. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller.

E. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

F. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

1. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V

2. Electrostatic Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
3. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
4. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
5. Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
6. IEEE Standard 587-1980
7. UL 864 Supply Line Transients
8. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000- 4-11)

G. In the event of the loss of normal power, non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
   1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
   2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, local ethernet port, or from a network workstation PC.

H. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller. Any exceptions to this must be approved by Texas State University Technical Services.

## 2.5 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:
   1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher-level computer for execution.
   2. All points shall be identified by up to 30-character point name and 16-character point descriptor minimum. The same names shall be used at the PC workstation.
      a.

B. DDC Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
   1. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible

time that will allow the equipment to achieve the desired zone condition by time of occupancy.

a. The SSTO program shall operate in both the heating and cooling seasons.

1). It shall be possible to apply the SSTO program to individual fan systems.

2). The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.

b. The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.

2. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.

a. It shall be possible to individually command a point or group of points.

b. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.

c. The operator shall be able to define the following information:

1). Time, day

2). Commands such as on, off, auto, and so forth.

3). Time delays between successive commands.

4). There shall be provisions for manual overriding of each schedule by an appropriate operator.

d. It shall be possible to schedule events up to one year in advance.

1). Scheduling shall be calendar based.

2). Holidays shall allow for different schedules.

3.

4. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

5. Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.

a.

C. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1.

D. Alarm management shall be provided to monitor and direct alarm information to

operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network. In compliance with this standard, there will not be a single point of failure for an entire building, and all the panels that reside within.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after-hours destinations) or based on priority.

4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200-character alarm message to more fully describe the alarm condition or direct operator response.

5. In critical applications, operator-selected alarms shall be capable of remote notification via text message or e-mail to a remote operator device.

| Instance | Name | Description | Priority | Ack Required |
|---|---|---|---|---|
| 0 | NC_Default | Default | 150,150,150 | None |
| 1 | NC_Pri1 | Life Safety | 0,0,0 | None |
| 2 | NC_Pri2 | Security Alarms | 40,40,40 | None |
| 3 | NC_Pri3 | High Alarms | 70,70,70 | None |
| 4 | NC_Pri4 | Med Alarms | 120,120,120 | None |
| 5 | NC_Pri5 | Low Alarms | 150,150,150 | None |
| 6 | NC_Pri6 | Fault Alarms | 210,210,210 | None |

| Alarm Priority | Example of Alarm Type |
|---|---|
| 1 | Fire Alarm Monitoring Points, Freon Leak Detectors, Emergency Purge Buttons, Etc.… |
| 2 | Security Alarms (At this time not something we will be using) |
| 3 | Equipment Safety Alarms: High Static, Low Static, Low Temp Detects, Etc.… (Anything that is a safety and will shut a piece of equipment off) |
| 4 | Device or Equipment Failures: L2SL Alarms, VFD Faults, Non-Safety Chiller Faults, Etc.…. |

| | |
|---|---|
| 5 | Out of Range alarms such as Temps, Duct Static Pressure, CHW/HW Differential Pressure, Etc….. |
| 6 | Non-Critical / Impacting Alarms such as: CO2, VOC, FDD, Filters, Etc…. |

E. A variety of historical data collection utilities shall be provided, to manually or automatically sample, store and display system data for points as specified in the I/O summary.

F. DDC Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

G.

## 2.6 FIELD NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) IP or MSTP Network Device through Field Networks/MSTP Network.

B. Each ASC or MSTP Network Device shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC IP or MSTP Network Device shall be a microprocessor-based, multi-tasking.

C. Terminal Equipment Controllers/MSTP Network Devices:

1. Provide for control of each piece of equipment, including, but not limited to, the following:

   a. Variable Air Volume (VAV) boxes

      - All VAV boxes will have a temperature sensor in the supply air section of the box.

   b. Constant Air Volume (CAV) boxes

      - All CAV boxes will have a temperature sensor in the supply air section of the box.

   c. Exhaust Fans

   d. Series/Parallel Fan Coil Units (FCU)

      - All FCU boxes will have a temperature sensor in the supply air section of the box

2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such

as 24V floating, 0-10V, 4-20mA control, allowing for interface to a variety of modulating actuators. As an alternative, provide DDC Controllers or other ASCs/MSTP Network Devices with industry standard outputs for control of all terminal equipment.

3. Room temperature sensors shall be provided as indicated on the drawings. Provide device as described in the Field Devices section of this specification.

4. All ASC's shall be able to host their own trending data until such time as it can be collected by the Automation System.

## 2.7 FIELD DEVICES

A. Provide instrumentation as required for monitoring, control, or optimization functions. All devices and equipment shall be approved for installation by Texas State University Technical Services.

B. Temperature Sensors

1. Digital room sensors (temperature only) shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room 55°F to 95°F (13°c to 35°C) adjustment. Liquid immersion temperature:

   a. Temperature monitoring range:

      - 0 to 250°F (-18° to 121°C)

   b. Output signal:

      - 1k Ω Pt RTD

   c. Well material:

      - 300 Series Stainless Steel Lead-Free

   d. Accuracy:

      - ±0.54°F(±0.4°C) @ 32°F(0°C)

   e. The sensor shall be mounted so that it extends to a minimum of 1/3 of the diameter of the pipe. For pipe greater than 10" diameter, thermowell shall be installed in a position 45° from the bottom of the pipe.

2. Duct (single point) temperature:

   a. Temperature monitoring range:

      - -40°F to 240°F (-7°C to 116°C)

   b. Output signal:

      - 1k Ω RTD

c. Reference resistance:

- 32°F (0°C)

d. Lengths:

- 4-inch (10 cm)
- 8-inch (20 cm)
- 18-inch (45 cm)

e. Thermistors are acceptable in VAV box applications downstream temperature control section of box where it's the manufacture's only native option.

f. Thermocouples with transmitters or pneumatic sensors with transmitters are not acceptable.

3. Duct Average temperature:

| | |
|---|---|
| Temperature monitoring range | 0°F to 120°F (-7°C to 49°C) |
| Output signal | 1k Ω Pt RTD |
| Reference resistance | 100Ω @ 32°F(0°C) |
| Accuracy | ±0.7°F(0.39°C) |
| Lengths | 8-foot (2.4m) flexible |
| | 16-foot (4.9m) flexible |
| | 25-foot (7.6m) flexible |

4. Outside air temperature:

a. Temperature monitoring ranges1k Ω RTD -58°F to 158°F (-50°C to 70°C)

0-10Vdc/4-20mA-58°F to 122°F (-50°C to 50°C)

b. Output signals:1k Ω RTD

0-10Vdc

4-20mA

c. Accuracies1k Ω RTD ±0.75°F (±0.4°C) @ 32°F (0°C)

0-10Vdc/4-20mA±1.4°F(±0.78°C): -13°F to 77°F (-25°C to 25°C)

C. Liquid Differential Pressure Transmitter

Ranges 0-5/30 inches H20

0-25/150 inches H20 0-125/750 inches H20

Output 4 – 20 mA DC

Calibration Adjustments Zero and span

Accuracy +-0.2% of span

Linearity +-0.1% of span

Hysteresis ±-0.05% of span

D. Differential pressure:

1. Unit for fluid flow proof shall be Penn P74.

   Range 8 to 70 psi

   Differential 3 psi

   Maximum differential pressure 200 psi

   Maximum pressure 325 psi

2. Unit for air flow shall be Siemens Building Technologies SW141.

   Set point ranges: 0.5” WG to 1.0” WG (124.4 to 248.8 Pa)

   1.0” WG to 12.0” WG (248.8 to 497.6 Pa)

E. Static pressure sensor:

| | |
|---|---|
| Range | 0 to .5” WG (0 to 124.4 Pa) |
| | 0 to 1” WG (0 to 248.8 Pa) |
| | 0 to 2” WG (0 to 497.7 Pa) |
| | 0 to 5” WG (0 to 1.2 kPa |
| | 0 to 10” WG (0 to 2.5 kPa) |
| Output Signal | 4 – 20 mA VDC Combined static error - 0.5% full range |
| Operating Temp. | -40º to 175º F (-40C to 79.5ºC) |

F. Air Pressure Sensor:

| | |
|---|---|
| Range: | 0 to 0.1 in. water (0 to 24.9 Pa) |
| | 0 to 0.25 in. water (0 to 63.2 Pa) |
| | 0 to 0.5 in. water (0 to 124.5 Pa) |
| | 0 to 1.0 in. water (o to 249 Pa) |
| | 0 to 2.0 in water 90 to 498 Pa) |
| | 0 to 5.0 in. water (0 to 1.25 kPa) |
| | 0 to 10.0 in. water (0 to 2.49 kPa) |
| Output signal | 4 to 20 mA |

| | |
|---|---|
| Accuracy | ±1.0% of full scale |

G. Humidity Sensors:

| | |
|---|---|
| Range | 0 to 100% RH |
| Sensing Element | Bulk Polymer |
| Output Signal | 4 – 20 mA DC |
| Accuracy | At 77°F (25ºC) ± 2% RH |

H. Utility Metering including but not limited to Chilled Water, Heating Water, Domestic Water, Steam, Steam Condensate, and Natural Gas

1. Energy BTU Measurement System Specifications ( Onicon BTU Displays)

   a. The entire Energy Measurement System shall be built and calibrated by a single manufacturer, ONICON Incorporated, and shall consist of a flow meter, two temperature sensors, a BTU meter, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST* traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer's two-year warranty.

   b. BTU Meter will integrate via BACnet MSTP or BACnet IP

2. Flow Totalization System Specifications (Onicon Flow Totalization Display)

   a. The entire Flow Totalization System shall be built and calibrated by a single manufacturer, ONICON Incorporated, and shall consist of a flow meter, and a totalization display.

   b. Flow Display will integrate via BACnet MSTP or BACnet IP

3. Flow Meter Specification (Onicon In-Line ElectroMag)

   a. Description: Provide an inline electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, transmitter, visual display, ANSI Class 150 or 300 mounting flanges, and calibration certificate.

   b. Application Range: This contractor shall be responsible for selecting the flowmeter options submitted based on the application. Flowmeter shall be constructed, calibrated, and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions and fluid characteristics which include but are not limited to pressure, temperature, conductivity, and viscosity.

   c. Sensing Technology: Electromagnetic velocity-measuring element.

   d. Design: Electromagnetic sensing element shall utilize a minimum of two 316L stainless steel electrodes to measure the average flow rate velocity.

e. Construction: Flowmeter shall consist of epoxy painted carbon steel outer body, 304 stainless steel flow tube and integral liner to be selected based on operating temperature and fluid. Individual calibration tag shall be attached indicating calibration and programming information.

f. Maximum Pressure Rating: 580 psig.

g. Maximum Temperature Rating: 266 deg F.

h. End Connections for NPS 1.0" and Larger: ANSI Class 150 Flange typical.

i. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served. Accuracy**:** Flowmeter shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:

j. Plus or minus 0.2% of rate from 1.6 to 33.0 ft/sec velocity.

k. Plus or minus 0.0033 ft/s at flow rates < 1.6 ft/s

l. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard directly traceable to international standards in accordance with ISO 9104:1991 and ISO 17025:2005.

m. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated

n. Display: Menu driven via three (3) button programming keys and shall include 16 character, 8 line graphic LCD backlit display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.

o. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

4. Flow Meter Specification (Onicon Insertion ElectroMag)

a. Description: Provide an insertion electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, integral transmitter, installation valves, installation depth gage and calibration certificate. Flowmeter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown.

b. Application Range: This contractor shall be responsible for selecting the flowmeter options submitted based on the application, refer to section for 230519.3.4 "Flowmeter Schedule by Application." Flowmeter shall be constructed, calibrated and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions and fluid characteristics which include but are not limited to pressure, temperature, conductivity and viscosity.

c. Sensing Technology: Electromagnetic velocity-measuring element.

d. Design: Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.

e. Construction: Wetted components shall be constructed of 316L stainless steel with attached tag indicating calibration information.

f. Maximum Pressure Rating: 400 psig.

g. Maximum Temperature Rating: 200 deg F.

h. End Connections for NPS 1.25" and Larger: 1" Male NPT Hot Tap Adapter fitting. Installation through 1" full port isolation valve, minimum.

i. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served.

j. Accuracy: Flowmeter shall provide calibrated outputs directly from the integral transmitter, throughout the operating range with the accuracy stated as follows:

k. Plus or minus 1.0% of rate from 2.0 to 20.0 ft/sec velocity (10:1 turndown).

l. Plus or minus 0.02 ft/sec below 2 ft / sec

m. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard that is traceable to NIST.

n. Optional Local Display: Local display shall provide instantaneous flow rate information and totalized flow information and shall be factory configured for connection to a specific flowmeter.

o. Operating and Installation Instructions: Installation and operating instructions shall be provided for each flowmeter. Refer to section 230519.3.4 "Flowmeter Schedule by Application" for additional installation requirements.

p. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

5. Flow Meter Specification (Inline Vortex, Insertion Vortex for High Flow Superheated Steam)

   a. Vortex Mass Flow Meter complete with integral density compensation to provide direct mass steam flow output.

      - The flow meter shall calculate mass flow corrected for density with real time calculations based on temperature and pressure measured directly from integral sensors.

      - Mass flow calculated externally to the flow meter will not be acceptable.

      - The flow meter shall be sized by the manufacturer for each specific

application and installed according to manufacturer's recommendations.

- Provide a flow straightener, if required to meet the manufacturer's minimum upstream straight pipe run requirement.
- Provide lateral and horizontal supports as required to minimize vibration at the meter location.
- Each individual flow meter shall undergo a multipoint point calibration against the manufacturer's N.I.S.T. traceable flow standards.
- The manufacturer shall provide a certificate of calibration for each meter.
- The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.
- Mass flow accuracy shall be within ± 1.5% of actual reading over the range of the meter, including all errors associated with velocity measurement, temperature and pressure measurement, and density compensation.
- The meter shall be provided with ANSI class 150 or class 300 flanges as required to meet system requirements.
- The maximum operating temperature shall be 5000 F. (Or 7500 F. when required).
- The flow meter body shall be constructed of 316L stainless steel and include a weather-tight NEMA-4X aluminum electronics enclosure.
- The meter shall display steam mass flow rate and mass flow total with an integral LCD display and support field programming of all parameters.
- The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.
- The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the Central Control System.
- In addition, an integral pulse output for steam mass flow totalization shall be provided.
- All outputs shall be linear with mass flow rate.
- Shall be integrated via BACnet IP or BACnet MS/TP

6. Flow Meter Specification (Inline Vortex, Insertion Vortex for High Flow Saturated Steam)
    a. Vortex Mass Flow Meter complete with integral density compensation to provide direct mass steam flow output.

b. The flow meter shall calculate mass flow corrected for density with real time calculations based on temperature measured by an integral 1,000 ohm platinum RTD.

c. Mass flow inferred from specified steam pressure or calculated externally to the flow meter will not be acceptable.

d. The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer's recommendations.

e. Provide a flow straightener, if required to meet the manufacturer's minimum upstream straight pipe run requirement.

f. Provide lateral and horizontal supports as required to minimize vibration at the meter location.

g. Each individual flow meter shall undergo a multipoint point calibration against the manufacturer's N.I.S.T. traceable flow standards.

h. The manufacturer shall provide a certificate of calibration for each meter.

i. The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

j. Mass flow accuracy shall be within ± 1.5% of actual reading over the range of the meter, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation.

k. The meter shall be provided with ANSI class 150 or class 300 flanges as required to meet system requirements.

l. The maximum operating temperature shall be 5000 F.

m. The flow meter body shall be constructed of 316L stainless steel and include a weather-tight NEMA-4X aluminum electronics enclosure.

n. The meter shall display steam mass flow rate and mass flow total with an integral LCD display and support field programming of all parameters.

o. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.

p. The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the Central Control System.

q. In addition, an integral pulse output for steam mass flow totalization shall be provided. All outputs shall be linear with mass flow rate.

r. Shall be integrated via BACnet IP or BACnet MS/TP.

7. Flow Meter Specification (Inline Turbine for Low Flow Steam) include Flow

Totalization Display and integrate via BACnet IP or BACnet MS/TP.

8. Flow Meter Specification (Insertion Thermal Mass Flow for Natural Gas and Compressed Air) and integrate via BACnet IP or BACnet MS/TP.

A. Electronic Airflow Measurement Stations and Transmitters (At Duct Locations).

1. Provide where indicated, Duct Mounted Airflow Measuring Systems capable of continuously monitoring the duct air volumes they serve. System components shall be by the same manufacturer to guarantee the overall accuracy and performance.

2. Duct Mounted Airflow Sensing Element Arrays:

a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc.; FE Series or equal as approved by the Engineer.

b. Material: Alloy 6063-T5 anodized aluminum (indoors duct) or Type 316L stainless steel (outside air or duct exposed to harsh chemicals)

c. Manifold sensing elements together in a 16-gage galvanized steel duct section with 90-degree undrilled flanges, fabricated to duct size.

d. Manifold Type 316L stainless steel duct mounted airflow sensing elements together in a Type 316L stainless steel duct section with 90-degree undrilled flanges, fabricated to duct size.

e. Airflow Straightening: Alloy 3003 aluminum honeycomb with opening 0.5 inch by 3 inches deep, or for outdoor air or corrosive environment Type 316L stainless-steel-bonded honeycomb airflow straightening section.

f. Designed and built to comply with and provide results according to accepted practice for duct system traversing defined in ASHRAE Handbook of Fundamentals, AMCA publication No. 203, and the Industrial Ventilation Handbook. Number of sensing ports on each element, and quantity of elements utilized at each installation, shall comply with ASHRAE 111 for equal area duct traversing.

g. Dual integral chambered design containing multiple total and static pressure sensing ports along leading edge of cylinder. Static pressure chamber shall incorporate dual offset static taps on opposing sides of averaging chamber to permit flow angle variations up to plus or minus 20 degrees in approaching airstream without affecting output value.

h. Capable of producing steady, non-pulsating signals of true total and static pressure, with accuracy of plus or minus 2 percent of actual flow for operating velocities as low as 100 fpm. Signal amplifying sensors requiring flow correction (K factors) for field calibration are prohibited.

i. Designed not to induce pressure drop greater than 0.18 inch at 4,000 fpm.

j. Self-generated sound rating of less than NC40. Sound level within duct shall not be amplified, nor shall additional sound be generated.

k. Approved by manufacturer for special configurations located outside of manufacturer's published installation guidelines, including requirements such as air equalizers and additional strategically placed measuring points.

3. Digital Airflow Signal Processors:

a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc.; MicroTransEQ or equal as approved by Technical Services.

b. Span: Factory calibrated to match the application.

c. Accuracy: Plus, or minus [0.25] [0.1] percent of full scale including non-linearity, hysteresis, deadband and non-repeatability.

d. Signal Conversion Resolution: 24-bit A/D and 12-bit D/A.

e. Temperature Effects: Less than 0.025 percent full scale per deg F

f. Over-pressure: 5 psig proof, 10 psig burst

g. Response: Less than 0.25 seconds for full scale input.

h. Noise Filtration: Response time to reach 98 percent of a step change adjustable from 0 to 200 seconds in 1 second increments.

i. Output: 4-20 mA

j. Enclosure: NEMA 1 rated flame-retardant ABS plastic (indoors) or NEMA 4X rated impact and corrosive resistant (outdoors)

k. Capable of twelve-point linearization and four-point flow correction.

l. Large backlit LCD for configuration and local indication of measured process.

m. Six button touch pad and password protected menus for field configuration of engineering units, process noise filtering, operating range, and alarm set points.

n. Automatic Zeroing Circuit: For operating velocities below 1,266 fpm include an automatic zeroing circuit that is field configurable for frequency of activation between one and twenty-four hours on 1-hour intervals. Signal processor output shall be locked and maintained at last given output value during automatic zeroing period so as not to interrupt automatic control process. Meter shall be auto calibrated to accuracy of plus or minus 1 count.

o. Temperature Compensation: Capable of accepting temperature input signal for air temperature indication, temperature signal transmission for remote readout, and air density compensation for standard or actual airflow calculations.

p. High/Lo Alarm: Contacts indicating low and/or high airflow conditions. Dry

contacts shall be rated for 5 amps at 30VAC/VDC and 10 amps at 120 VAC resistive load.

q. Monitoring and configuration shall be performed through BACnet®-MS/TP communication network.

B. Fan Inlet Airflow Measuring Station

1. Provide where indicated, Fan Inlet Airflow Measuring Systems capable of continuously monitoring the fan capacities (air volumes) they serve. Each System shall consist of a Pitot-type airflow sensing element array suitable for mounting in each inlet of the fan and a digital airflow signal processor. System components shall be by the same manufacturer to guarantee the overall accuracy and performance.

2. Fan Inlet Airflow Sensing Element Arrays:

a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc., Model FE-1050

b. Material: Alloy 6063-T5 anodized aluminum

c. Designed and built to comply with and provide results according to accepted practice for duct system traversing defined in ASHRAE Handbook of Fundamentals, AMCA publication No. 203, and the Industrial Ventilation Handbook. Number of sensing ports on each element, and quantity of elements utilized at each installation, shall comply with ASHRAE 111 for equal area duct traversing.

d. Dual integral chambered design containing multiple total and static pressure sensing ports along leading edge of cylinder. Static pressure chamber shall incorporate dual offset static taps on opposing sides of averaging chamber to permit flow angle variations up to plus or minus 20 degrees in approaching airstream without affecting output value.

e. Capable of producing steady, non-pulsating signals of true total and static pressure, with accuracy of plus or minus 2 percent of actual flow for operating velocities as low as 100 fpm. Signal amplifying sensors requiring flow correction (K factors) for field calibration are prohibited.

f. Designed not to induce pressure drop greater than 0.18 inch at 4,000 fpm

g. Self-generated sound rating of less than NC40. Sound level within duct shall not be amplified, nor shall additional sound be generated.

h. Designed not to be used on fan inlet applications where narrowest diameter of inlet cone is less than 12 inches without prior manufacturer approval or on fans having inlet guide vanes. Use of one static element and one total pressure element on fan inlets is prohibited.

i. Approved by manufacturer for special configurations located outside of

manufacturer's published installation guidelines.

3. Digital Airflow Signal Processors:

   a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc.; MicroTransEQ or equal as approved by the Engineer.

   b. Span: Factory calibrated to match the application.

   c. Accuracy: Plus or minus 0.25 percent of full scale including non-linearity, hysteresis, deadband and non-repeatability.

   d. Signal Conversion Resolution: 24-bit A/D and 12-bit D/A.

   e. Temperature Effects: Less than 0.025 percent full scale per deg F

   f. Over-pressure: 5 psig proof, 10 psig burst

   g. Response: Less than 0.25 seconds for full scale input.

   h. Noise Filtration: Response time to reach 98 percent of a step change adjustable from 0 to 200 seconds in 1 second increments.

   i. Output: 4-20 mA

   j. Enclosure: NEMA 1 rated flame-retardant ABS plastic (indoors) NEMA 4X rated impact and corrosive resistant (outdoors)

   k. Capable of twelve-point linearization and four-point flow correction.

   l. Large backlit LCD for configuration and local indication of measured process.

   m. Six button touch pad and password protected menus for field configuration of engineering units, process noise filtering, operating range, and alarm set points.

   n. Automatic Zeroing Circuit: For operating velocities below 1,266 fpm include an automatic zeroing circuit that is field configurable for frequency of activation between one and twenty-four hours on 1-hour intervals. Signal processor output shall be locked and maintained at last given output value during automatic zeroing period so as not to interrupt automatic control process. Meter shall be auto calibrated to accuracy of plus or minus 1 count.

   o. Temperature Compensation: Capable of accepting temperature input signal for air temperature indication, temperature signal transmission for remote readout, and air density compensation for standard or actual airflow calculations.

   p. High/Lo Alarm: Contacts indicating low and/or high airflow conditions. Dry contacts shall be rated for 5 amps at 30VAC/VDC and 10 amps at 120 VAC resistive load.

   q. Monitoring and configuration shall be performed through BACnet®-MS/TP communication network.

4. Multiple Fan (Fan Array) Airflow Measuring Systems – (Fan Array Air Handlers)

5. When multiple fans (fan array) are serving a common duct, the air handling manufacturer shall provide airflow measurement pressure taps for each individual fan and shall provide the factory determined flow coefficient for the fans being furnished. If pressure taps are not available for the fans being supplied, the use of Pitot-type fan inlet airflow sensors is acceptable. The building automation system (BAS) contractor shall furnish and install a fan array airflow totalizing system which monitors the airflow capacity of each individual fan based on the differential pressure and flow coefficient and shall provide a totalized airflow rate to the BAS for control and monitoring purposes.

6. Fan Array Airflow Totalizing System:

    a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc., Model FAATS-1000

    b. Accuracy: Plus, or minus 0.25 percent of full scale including non-linearity, hysteresis, deadband and non-repeatability for each fan in the array.

    c. Signal Conversion Resolution: 16-bit A/D and 12-bit D/A.

    d. Output: Field selectable for 4-20 mA

    e. Human-Machine-Interface (HMI) Panel: For air volume indication and configuration of the fan array airflow totalizing system. The HMI shall provide continuous on-screen indication of each individual fan's airflow rate and operational status and shall display the totalized airflow rates for each fan array numerically and graphically as a percent of total design flow. The graphic screen shall be configured to match the fan array layout. Individual fan diagnostics via the HMI panel to indicate the measured differential pressure being reported by each individual fan as well as transducer output. Automatic zero and span calibration for each individual differential pressure transducer performed via the HMI.

    f. Alarms: Individual fan failure alarms and warning alarms for when an individual fan's airflow rate is either above or below the average for all fans by a programmable percentage value. A failed fan alarm initiated when the airflow rate for an individual fan goes to zero. The fan (or fans) that are in an alarm state shall be shown on the HMI graphics screen in flashing yellow for warning and red for failed.

    g. Network Communication: For monitoring and control purposes via communication network to the BAS. The network information shall provide individual fan information and remote configuration of all programmable values.

    h. Enclosure: NEMA 1 Steel (Indoors) [NEMA 4X Steel (Outdoors)

    i. Remote Panel: For fan array monitoring systems measuring both supply and

return fan arrays in a single air handling unit, provide a remote transducer panel to minimize the pneumatic tubing.

7. Outdoor Airflow Measurement Systems – Outdoor Air Damper (if required)

    a. Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc., Model OAFE-1550 or equal as approved by the Engineer.

    b. Measure minimum amount of outside air as recommended by ASHRAE 62.1-2010, Ventilation for Acceptable Indoor Air Quality, and provide input to building automation system linear to measured airflow rate.

    c. Tested in accordance with AMCA 610, Figure 4, Methods of Testing Airflow Measurement Stations for Rating, and AMCA 611, Certified Ratings Program – Airflow Measurement Performance, in an AMCA-registered testing facility and bear the AMCA International Certified Ratings Seal for Airflow-Measurement Station Performance.

    d. Accurate to plus or minus 0.5 percent over operating range of 200 to 1,200 fpm and within plus or minus 5 percent for operating ranges as low as 100 fpm

C. Electrical Power Meters: (Shark Meters)

1. Accepted Models of Shark Electrical Power Meters with ProtoCom-KT communications gateways.

2. Current Transformers (CT's) Shall be 0.3% Accuracy Class, with 5 Amp Secondaries. CT's are preferred to be Solid Core, but Split Core can be installed with approval from Texas State University Technical Services.

3. Voltage Transformers shall be 0.3% Accuracy Class and the Secondary Voltage shall be 115V.

4. Single Point Monitoring:

    a. The meter shall be UL listed and CE marked.

    b. The meter shall be designed for Multifunction Electrical Measurement on 3 phase power systems. The meter shall perform to spec in harsh electrical applications in high and low voltage power systems.

        - The meter shall support 3 Element Wye, 2.5 Element Wye, 2 Element Delta, 4 wire Delta systems.
        - The meter shall accept universal voltage input.
        - The meter's surge withstand shall conform to IEEE C37.90.1.
        - The meter shall be user programmable for voltage range to any PT ratio.
        - The meter shall accept a burden up to 0.018 W at 120 V.

- The meter shall accept a voltage input range of up to 576 volts Line to Neutral, and up to 721 volts Line to Line.
- The meter shall accept a current reading of up to 11 Amps continuous.
- The meter shall have color-coordinated voltage and current inputs.
- The meter shall have a phasor diagram, through software, that clearly shows wiring status.

c. The meter shall use a dual input method for current inputs. Method one shall allow the CT to pass directly through the meter without any physical termination on the meter. The second method shall provide additional termination pass through bars, allowing the CT leads to be terminated on the meter. The meter must support both termination methods.

- Fault Current Withstand shall be 100 A for 10 seconds, 300 A for 3 seconds, and 500 A for 1 second.
- The meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable.
- The meter shall accept a burden of 0.005 VA per phase, Max at 11 A.
- The meter shall begin reading at 0.1% of the nominal current.
- Pass through wire gauge dimension of 0.177” / 4.5 mm shall be available.
- All inputs and outputs shall be galvanically isolated to 2500 V AC.
- The meter shall accept current inputs of Class 10: (0.005 to 11) A, 5 A Nominal, 18 A max and Class 2 (0.001 to 2) A, 1 A Nominal Secondary, 2 A max.

d. The meter shall have an accuracy of +/- 0.1% or better for voltage and amperes, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC62053-22 (Class 0.2%) and ANSI C12.20 (Class 0.2%). The meter shall have a Frequency measurement accuracy of not less than 0.007 Hz.

- The meter shall provide true RMS measurements of voltage, - phase to neutral and phase-to-phase; and current, per phase and neutral.
- The meter shall calculate RMS readings, sampling at over 400 samples per cycle on all channels of measured readings continuously, with no cycle blind spots.

e. The meter shall utilize 24 bit Analog to Digital conversion.

- The meter shall provide THD (Total Harmonic Distortion). Harmonic magnitude recording to the 40th order shall be available for voltage and

current harmonics.

- The meter shall provide a simultaneous voltage and current waveform recorder.
- The meter shall be capable of recording 512 samples per cycle for a voltage sag or swell or for a current fault event.
- The meter shall provide pre and post-event recording capability.
- The meter shall have a programmable sampling rate for the waveform recorder.
- The meter shall have an advanced DSP design that allows power quality triggers to be based on a 1 cycle updated RMS.
- Up to 319 events shall be recorded.
- The meter shall store waveform data in a first-in, first-out circular buffer to ensure that data is always being recorded.

f. The meter shall include a three-line, bright red, .56" LED display.

- The meter shall fit in both DIN 92 mm and ANSI C39.1 round cut-outs.
- The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.

g. The meter shall include a three-line, bright red, .56" LED display.

- The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.

h. The meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.

i. The meter shall include virtual measurement upgrade packs (V-Switch™ keys), which shall allow user to upgrade in field without removing installed meter.

- The four Virtual Upgrade packs shall be:
  - Volts, Amps, kW, kVAR, PF, kVA, Freq., kWh, kVAh, kVARh, and I/O Expansion - V1
  - Above with 2 Megabytes of memory for Data-logging - V2
  - Above with 128 samples per cycle waveform recording and 10 Megabytes memory – V3.
  - Above, with 512 samples per cycle waveform recording and 128 Megabytes memory - V4.

- The V-Switch™ keys must be able to be implemented without physically removing the installed meter.

j. The meter shall include 2 independent communications ports on the back and face plate, with advanced features.

- One port shall provide RS485 communication speaking Modbus ASCII, Modbus RTU, or DNP3 protocol through the back plate. Baud rates shall be from 1200 baud to 57600 baud for the RS485 port.
- The meter shall have a USB port (through the faceplate) as the second standard communication port, which shall allow the unit to be set up and programmed using a laptop computer. Baud rate for the USB port shall be 57600; Modbus ASCII protocol, no Parity, 8 Data bits, and 1 Stop bit shall be supported.

k. The meter shall provide user configured fixed window or rolling window demand. This shall allow the user to set up the particular utility demand profile.

- Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features.
- All other parameters shall offer max and min capability over the user selectable averaging period.
- Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.
- The meter shall provide an update rate of every 6 cycles for W, VAR and VA and Wh, VARh, and VAh. All other parameters shall be every 60 cycles.

l. The meter shall support a power supply of (90 to 265) V AC or (100 to 370) V DC.

m. The meter shall provide Limits/Alarms and control capability as follows:

- Limits can be set for any measured parameter.
- Up to 16 limits can be set.
- Limits shall be based on % of Full-Scale settings.
- Manual relay control shall be available through software.
- Relay set delays and reset delays shall be available.
- Relay control shall be available through DNP3 over Ethernet with the Ethernet Option card.

n. The meter shall have data logging capability of up to 128 MB memory. The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created.

- The meter shall have up to six historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs. The duration of a historical log with 4 data channels being recorded at 15-minute intervals shall be 76 months.
- The meter shall have a log for Limits/Alarms. The Limits log shall provide magnitude and duration of an event, timestamp, and log value. The log must be capable of recording up to 2048 events.
- The meter shall have a log for System Events. The System Events log shall record the following occurrences with a timestamp: Demand Resets, Password Requests, System Startup, Energy Resets, Log Resets, Log Reads, Programmable Settings Changes, and Critical Data Repairs.
- The meter shall have a log for I/O changes. The I/O Change log shall provide a time-stamped record of any Relay Outputs and any Input Status changes. The log must be capable of recording up to 2048 events.
- The meter with Virtual Upgrade packs 3 and 4 shall have a log which is capable of recording a waveform both when a user-programmed value goes out of limit and when the value returns to within limit. Up to 319 waveform events can be stored.
- The meter shall have a log for PQ events, with millisecond recording of waveform events.

o. The meter shall have I/O expandability through two Option card slots on the back.

- The cards shall be capable of being installed in the field, without removing the meter from installation.
- The meter shall auto-detect the presence of any I/O Option cards.
- The Option card slots shall accept I/O cards in all of the following formats: 100BaseT Ethernet Communication Card; Four Channel Bi-directional 0-1mA Output Card; Four Channel 4-20mA Output Card; Two Relay Outputs/2 Status Inputs Card; Four Pulse Outputs/4 Status Inputs Card; Fiber Optic Card; IEC 61850 Protocol Ethernet Network Card; RS232/RS485 Serial Communication Card.
- The meter shall be capable of accepting any combination of up to two cards
    - When two Ethernet cards are installed in the meter, an independent IP address and MAC address shall be assignable to each card.
- The Ethernet Option Card shall provide the meter with 100BaseT Ethernet

functionality. The Ethernet Option card shall:

- Allow the meter to speak with 12 simultaneous sockets of Modbus TCP, so that multiple requests for data can be received simultaneously.
- Allow the meter to speak with 5 simultaneous sockets of DNP3 over TCP/IP.
- Allow the meter to speak with both Modbus TCP and DNP3 over Ethernet simultaneously.
- Allow auto transmit/receive detection for straight or crossover RJ45 cables.
- Provide an embedded Web server that allows access to metered readings through the Internet, using any standard Web browser from a PC, smart phone, or tablet PC.
- Provide email on configured alarms.
- Provide email notification of meter status and reading data on a programmed schedule.

- The 1mAO Option Card shall provide the following features:
  - 4 channel, bi-directional 0-1 mA outputs.
  - Assignable to any measured parameter.
  - 0.1% of Full-Scale accuracy throughout range and load.
  - Maximum load impedance to 10 kΩ, with no accuracy losses.
- The 20mAO Option Card shall provide the following features:
  - 4 channel, 4-20 mA outputs.
  - Assignable to any measured parameter.
  - 0.1% of Full-Scale accuracy throughout range and load.
  - Maximum load impedance to 850 Ω, with no accuracy losses.
  - Loop powered using up to 24 V DC.
- The Relay Output/Status Input Option Card shall provide the following features:
  - 2 Relay outputs, 2 Status inputs.
  - Status Inputs – Wet/Dry Auto Detect up to 150 V DC.
  - Trigger on user-set Limits/Alarms.

- Set delays and Reset delays
- The Pulse Output/Digital Input Option Card shall provide the following features:
- KYZ pulse/4 Status inputs.
- Programmable to any energy parameter and pulse value.
- Programmable to End of Interval pulse.
- Can function for manual relay control and limit-based control.
- 120 mA continuous load current.
- DNP3 input.

- The Fiber Optic Option Card shall provide the following features:
  - Built in logic to mimic RS485 half-duplex bus, allowing the user to daisy chain meters for low installation cost.
  - ST Terminated Option.
  - Versatile Link Terminated Option.
  - Modbus and DNP3 protocols available
- The IEC 61850 Protocol Ethernet Network Option Card shall provide the following features:
  - Integrates into any IEC 61850 network.
  - Provides support for Modbus TCP and IEC 61850 protocols simultaneously.
  - Configurable for multiple logical nodes.
  - Provides buffered and unbuffered reporting.
  - Is certified by a 3rd party Authorized IEC 61850 Test Laboratory.
  - Is capable of supporting two Ethernet cards with separate /IP addresses, each running IEC 61850 protocol.
- The RS1S Communication card adds another serial communication port - either RS232 or RS485.

p. The meter shall have transformer loss, line loss, and total substation loss compensation.

q. The meter shall compensate for errors in current transformers and potential transformers.

- Errors shall include voltage, multipoint current, multiphase angle, and better than .01% resolution.

r. The meter shall internally record and store Time of Use data in a perpetual TOU calendar.

- The following Time of Use parameters must be included:
  - Bi-directional consumption and demand.
  - Configurable accumulators.
  - Up to four seasons and 12 months.
- The meter must provide the following TOU information for all rates in real time:
- Current month accumulations.
- Previous month accumulations.
- Current season (or weekly, or daily) accumulations.
- Previous season (or weekly, or daily) accumulations.
- Total accumulations to date.
- Cumulative Demand.
- Continuous cumulative demand shall be available.

s. The meter shall provide multi-level Cyber Security:

- The meter shall have highly secure encrypted passwords of up to 30 characters in length.
- The meter's security shall allow for 9 user IDs and passwords.
- There shall be one admin level and up to 8 customizable user levels.
- There shall be password fail timeouts.
- Password restriction shall be available for most meter functions.

t. The meter shall be able to be stored in (-20 to +70) °C.

- Operating temperature shall be (-20 to +70) °C.
- NEMA 1 faceplate rating shall be available.
- Humidity rating to 95% R.H.
- Standard conformal coating on PCBs.

u. The meter shall have a standard 4-year warranty.

v. The Unit shall have an Add-on Protocol Module. The enclosure can be shipped with:

- One Add-on Protocol Module Option (ProtoCom) shall enable BACnet/IP and BACnet MS/TP communication.

5. Multi-point Metering Unit (Shark Multipoint Meters)

a. Multi-Point Electrical Power Meters needs to be ordered with ProtoCom Communications Gateway.

b. The Unit shall be UL listed and CE marked.

c. The metering system shall come pre-wired in a UL approved NEMA 1 enclosure.

- The enclosure shall come with Voltage fuses and shorting blocks for use with current transformers.
- The enclosure shall have a lockable door.
- The enclosure shall have a display for remote or local reading.
  - The display shall be available in two window sizes - 3.5" and 5.7".
  - The display shall be a touch-screen LCD display, NEMA 4X (Indoor Use) capable.
  - The display shall support over 65k colors.
  - The display shall support RS485 serial and RJ45 Ethernet communication, simultaneously.
  - The display shall auto-detect the type of communication being used.
  - The display shall be pre-configured to display readings for both the 8 three phase meters and the 24 single phase meters circuit configurations.
  - The display shall provide the names of each circuit being metered.
  - The display shall also provide important diagnostic data like meter date and time, a graphical phasor diagram, and out of limit conditions.
  - The display shall be capable of displaying non-electrical parameters like water, gas, and steam usage.
  - The unit shall have the capability of utilizing both a local and remote display, simultaneously.

d. The Unit shall consist of either of two circuit configurations: 8 multifunction

electrical measuring points (meters) for 3 phase power systems or 24 multifunction electrical measuring points (meters) for single phase power systems. The Unit's meters shall perform to spec in harsh electrical applications in high and low voltage power systems.

- The Unit shall support 3 element Wye or single phase 3-wire and 2-wire systems.
- The Unit shall accept universal voltage input.
- The Unit's surge withstand shall conform to IEEE C37.90.1.
- The Unit shall be user programmable for voltage range to any PT ratio.
- The Unit shall accept a burden of up to .09VA per phase, Max at 600 Volts, and 0.014VA at 120 Volts.
- The Unit shall accept a voltage input range of up to 576 Volts Line to Neutral, and up to 721 Volts Line to Line with a universal voltage system input.
- The meters shall accept a current reading of up to 20 Amps continuous.

e. The Unit/meters shall have color-coordinated voltage and current inputs. The Unit's meters shall have an accuracy of +/- 0.5% or better for Volts and Amps, and 0.5% for power and energy functions. The Unit shall meet the accuracy requirements of IEC62053-22 (Class 0.5%) and ANSI C12.201(Class 0.5%).

- The meters shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase (for the three-phase meter circuit configuration) and neutral.
- The Unit shall provide sampling at 400+ samples per cycle on each measured channel simultaneously, at 24-bit resolution.

f. The Unit shall have optional data-logging memory of up to 32MB. With data-logging, the Unit shall support:

- Two pre-configured Historical logs: Log 1 for trending Voltage and Frequency, Log 2 for trending Energy use over time.
- An Alarm/Limits log that records the state of the 16 limits that can be programmed for the meter.
- A System Events log to store events that happen in, or to the meter, including Startup, reset commands, log retrievals, and attempts to log on with a password.
- An I/O Change log to record changes in the inputs and outputs of the Relay Output/Status Input board.

g. The Unit's meters shall be traceable revenue meters. The Unit which shall contain at least 8 utility grade test pulses allowing power providers to verify and confirm that the meters are performing to their rated accuracy.

h. The Unit shall offer the following communication ports.

- Com 1 shall support RS485 and optional RJ45 Ethernet/802.11b Wi-Fi. It shall support Modbus RTU, Modbus ASCII, and Modbus TCP; and baud rates from 9,600 to 57,600.
- Com 2 shall be a USB Serial port. It shall support Modbus ASCII and a baud rate of 57,600.
- Com 3 shall support RS485. It shall support Modbus RTU and Modbus ASCII; and baud rates from 9,600 to 57,600.

i. The Unit shall have a Relay Output/Status Input board.

- The board shall have 2 Relay Outputs for control applications. The relay outputs shall be able to be triggered by the user-programmed limits in the meters. The user shall be able to assign up to 16 limits, including below-and above-limit conditions for any value the meter measures.
- The board shall have 4 KYZ Counting Inputs. The KYZ inputs shall be able to be configured to count pulses from gas, water, condensate, and other commodity measuring devices.

j. The Unit shall provide user configured fixed window or rolling window demand, so the user can set up the particular utility demand profile.

- Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features. All other parameters shall offer max and min capability over the user selectable averaging period.
- Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.

k. The Unit shall have an Add-on Protocol Module. The enclosure can be shipped with:

- One optional Add-on Protocol Option Module (ProtoCom) shall enable BACnet/IP and BACnet MS/TP.

l. The Unit shall be upgradeable after installation. Upgrade packs accessed through the optional Com port shall allow the base model (V1) to be upgraded to support basic load profiling with 2MB of Memory (V2) and upgraded to support advanced load profiling with 32MB of memory (V3).

m. The Unit shall consist of an all-metal enclosure and shall have the following physical properties:

- The Unit shall measure 7.6(L) x 11.28(W) x 4.36(H) in / 19.3(L) x 28.65(W) x 11.07(H) cm.
- The Unit shall be able to be mounted within an electrical panel.
- The Unit shall have a stud-base connection for current inputs.

n. The Unit shall have a 4-year warranty.

## PART 3: EXECUTION

### 3.1 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:

1. Construct and maintain project schedule
2. On-site coordination with all applicable trades and subcontractors
3. Authorized to accept and execute orders or instructions from owner/architect
4. Attend project meetings as necessary to avoid conflicts and delays
5. Make necessary field decisions relating to this scope of work
6. Coordination/Single point of contact
7. Responsible for identifying issues with Engineered Sequences, requested instrumentation, and poor control installation topology, and submitting required documentation to Constracting Chain for issue resolution.

### 3.2 SEQUENCE OF OPERATION

A. Philosophy of Sequences:

1. All control sequences shall include equipment-operating strategy, graphics, alarm messages, logging, and reporting and point list requirements.
2. The purpose of the control system is to provide a management tool for operating the complex in an efficient manner. Therefore, as much practical operating information is to be programmed into the control system as part of the base package, as possible.

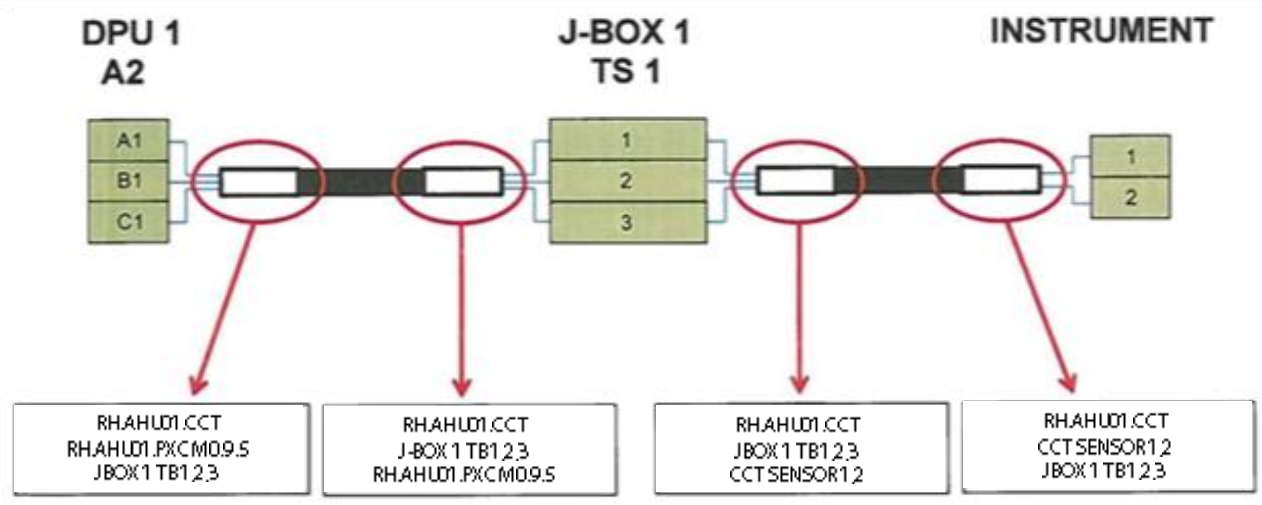
B. Prior to application programming, the Controls Contractor shall meet with the Owner and Engineer to determine point name formats, Alarm Message Formats, Graphic Formats, Report Formats, Data Logging formats and final sequences of operation.

C. Specific Sequences of Operation

### 3.3 INSTALLATION

A. Wiring.

1. All wire and cable used in the installation of the system shall be marked to identify it as part of the BAS. Cable shall be shaded blue for outputs, and white for inputs throughout the installation.
2. Cable for building level network shall have low capacitance characteristics to support specified baud rate ASC's.
3. Wires should be labeled with Slide-On Labels mechanically printed, not hand-written.
4. Each Termination Points should have a label with three lines:
   a. The top line indicates the point name
   b. The second line indicates the current location where the line is landed
   c. The third line indicates where the other end of the wire is landed
5. Lines should be labeled in every junction box the line passes through, if an actual junction is made which splices the line between panel and device.




## 3.4 START-UP AND COMMISSIONING

A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The Installing Contractor shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. These procedures apply to the BAS and all gateways to other systems, including fire alarm/life safety.

B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without

prior approval of owner.

C. Prior to commissioning proceeding, the following prerequisites shall be met and confirmed in writing:

1. All control hardware is installed.
2. Wiring installation is complete.
3. All terminations for power and control wiring are complete.
4. Power is from final, permanent sources.
5. Mechanical/electrical systems are substantially complete.
    a. Duct caps are removed, ductwork completed.
    b. Air and water systems are balanced.
6. Database is complete
    a. Points, including alarms
    b. Programming, including real-time control software and time-of- day scheduling, and the programming review has been completed between Texas State University Technical Services and Controls Contractor, as described in Section E.7.a. of this Standard.
    c. Graphics, if workstation is present.
7. Coordination is completed to allow full access to systems
    a. Shutdowns, if required, are scheduled and agreed upon
    b. Coordination with other contractors who impact the startup/checkout schedule

D. The Controls Contractor shall prepare a commissioning process book with all procedures, forms and submittal information. Plan shall include the following information:

1. Track that prerequisites for checkout have been completed, with dates.
2. List of parties to be involved in checkout and required for signoff.
    a. Owner’s rep
    b. Engineer
    c. Technical Services Representative
    d. Other as required
3. List of procedures and tasks to be completed.

4. Collection of forms to capture tasks, results, dates, and signoffs for each category of task.
5. Warranty letters
6. Acceptance letter indicating executive turnover with signatures

E. Commissioning plan tasks and procedures will be included as per the following:

1. Field panel checkout
    a. Verify enclosure is not mounted on vibrating surface
    b. Verify class I and class II wiring are separated within enclosure
    c. Check for shorts/grounds/induced voltages/proper voltages
    d. Verify proper point terminations in accordance with as-builts
    e. Verify that all modules are in proper place and addressed
    f. Verify proper power voltage
    g. Load database and programming
    h. Startup the panel
    i. Point and device checkout
    j. FLN/MSTP/IP Network and Power Trunk Diagrams are available for reference.
2. Analog input point checkout
    a. Verify the correct wiring terminations per the design documentation package, at the field panel. Verify that all wiring and terminations are neat and labeled appropriately.
    b. Verify the point address by checking that the analog input instrument is wired to the correct piece of field equipment. Do this by altering the environment at the sensing element or by disconnecting one of the wires at the sensor and verifying that the reading at the field panel has reacted to this change.
    c. Verify the point database to be correct, (i.e., alarm ability, alarm limits, slope/intercept, engineering units, etc.). Verify that the correct change of value (COV) limit has been defined.
    d. Verify the sensor has the correct range and input signal. (i.e., 20- 120 DEG F, 4 - 20 ma). Verify that the device is mounted in the correct location and is wired and installed correctly per the design documentation package.
    e. Set-up and/or calibrate any associated equipment (i.e., panel LCD meters, loop isolators, etc.). Verify that these auxiliary devices are mounted in the correct location and are wired and installed correctly per the design documentation

package.

f. Verify the correct reading at the field panel using appropriate connection method. Verify that any associated LCD panel meters indicate the correct measured value.

3. Digital input point checkout

   a. Verify the device is correctly wired and terminated as shown in the design documentation package. Verify that all wiring and terminations are neat and properly secured.

   b. Verify the point address by verifying that the digital input is correctly terminated at the controlled piece of equipment.

   c. Verify the point database is correct (i.e., point name, address, alarm ability, etc.).

   d. Set-up and/or calibrate the associated equipment, i.e. high/low temperature detector, high/low static switch, flow switch, end switch, current relay, pressure switch, etc. is mounted in the correct location, and is wired and installed correctly per the control system installation drawings.

   e. With the controlled equipment running or energized as described in the digital output checkout procedures, verify the correct operation of the digital input point and associated equipment by putting the digital input monitored equipment into its two states. Verify that the proof or status point indicates the correct value at the operator's terminal and that the status led is giving the proper indication in each mode of operation (on/off).

4. Digital output point checkout

   a. Verify that device is correctly wired and terminated as shown in the design documentation package.

   b. Verify that the correct voltage is utilized in the circuit.

   c. Verify the point database to be correct (i.e. point name, address, etc.).

   d. Check and verify that the end device responds appropriately to the digital output(s).

   e. After verifying the set-up and operation of any associated digital input/proof points, check and verify correct operation of the logical point and associated equipment by commanding the point to all possible states (i.e. off, on, fast, slow, auto, etc.). Verify that the defined proof delay is adequate for all modes of operation.

   f. If any interlocked equipment exists that has independent hand-off- auto or auxiliary control wiring, verify correct operation of it. Also check that any interlocked equipment such as EP switches for damper operation or exhaust and

return fans are wired correctly and operate correctly.

g. Verify that the controlled piece or pieces of equipment cannot be cause to change state via the digital output if an associated hand- off-auto switch is in the hand /on or hand/off mode of operation, unless specified as a fireman's override point etc.

5. Analog output point checkout

   a. Verify the correct wiring or piping terminations per the design documentation package, at the field panel. Verify that all wiring and piping terminations are neat and dressed.

   b. Ensure that the correct output device(s) are installed per the Control System Installation Drawings. (i.e., transformers, power supply, etc.). Verify that these devices are installed, wired and piped correctly. Verify that any configuration jumpers are in the proper settings for the required application. Verify related transformers are fused in accordance with installation drawings.

   c. Verify the point database to be correct. Verify that the correct COV limit has been defined.

   d. Verify the point address by checking that the analog output is wired to the correct equipment.

   e. Verify that the controlled device is calibrated (i.e., 4-20 ma variable frequency drive, etc.) and is in the correct location, and is wired and installed correctly per the design documentation package. If the controlled device is not calibrated, then a three-point (high, low and mid- point) calibration procedure shall take place. Verify proper operation of the end device. When calibration has been verified, ensure that installation drawings, point database, and PPCL have been updated.

   f. Set-up and or calibrate any associated equipment, (i.e., panel LCD meters, loop isolators, etc.). Also verify that these auxiliary devices are mounted in the correct location and are wired and installed correctly per the design documentation package.

   g. After verifying the set-up and operation of any associated equipment check for the correct operation of the logical point and associated equipment by commanding the analog output to the top and bottom of its range. Verify that the control device(s) responded appropriately as indicated by the design documentation package. Check to ensure that all network terminals; host console devices, etc. can also command these outputs.

   h. Check that pilot positioners and LCD panel meters indicate the correct values.

6. Terminal equipment controller checkout

a. Load program database

b. Enable programs

c. Verify sequence of operations

7. Programming checkout

   a. All Programming will be reviewed by Texas State University Technical Services, and the Controls Contractor to look for mistakes in the code, and to ensure that the written code matches the engineered sequence of operations for all systems provided in the approved Construction Documents. After the review has been completed Technical Services will sign the provided checkout sheet for each system and sequence of operation. This will be completed prior to Database installation into the DDC Panels.

   b. Physical testing of the units will still be conducted via Commissioning utilizing the following methodology. The following are sample sequence of operations tests. The intent of these procedures is to provide a plan of action to verify system operations via block checks of the project specific sequence of operations. The procedures may be used in this format, or one procedure to a page should more detail be required. The procedures outlined below should be verified for accuracy and may be modified to meet your specific requirements.

      - DESCRIPTION OF TEST: AHU Alarm Checkout. Verify AHU-1 discharge air temperature alarming is operational and is received at the designated terminal.

      - INPUT TO TRIGGER TEST: Change discharge temperature high alarm limit through software to a value below the current discharge temperature (discharge temperature - 10 Deg F).

      - EXPECTED OUTCOME: A high temperature alarm will be received per the Alarm Definition Report at its designated terminal.

   c. Provide signoff sheet with indication for test Pass, Fail, Date of test and Initials for signoff.

8. Customer acceptance

   a. Provide customer system acceptance sign-off sheet listing job name, project number, and the following statement: “THIS SYSTEM HAS BEEN FULLY DEMONSTRATED AND EXPLAINED IN ACCORDANCE WITH THE CONTRACT AND IS APPROVED FOR ACCEPTANCE BY THE OWNERS REPRESENTATIVE ON (date) BY (name). THIS SYSTEM IS ACCEPTED WITH THE FULL KNOWLEDGE THAT THE INSTALLATION MUST UNDERGO A TOKEN DEBUGGING PERIOD AND THE UNDERSTANDING THAT ALL ITEMS ON THE ATTACHED LIST WILL BE CORRECTED IN A TIMELY MANNER FROM THE ABOVE DATE. I ACCEPT THIS SYSTEM WITH EXCEPTIONS AS NOTED BY THE ATTACHED DETAILED LIST.”

b. Provide the following spaces for signoff:

1). Customer signatures title and date

2). DDC contractor signatures title and date

3). Contract number

c. The Controls Contractor shall provide written notification at key turnover points:

1). Warranty period partial turnover (if required)

2). Warranty period final turnover

3). Customer acceptance letter

d. Acceptance shall not occur until owner verifies that training has been delivered, warranty has been signed off, and operating and maintenance manuals have been delivered.

## 3.5 TRAINING

A. The Controls Contractor shall provide comprehensive training to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal working hours of 7:00 AM to 4:00 PM weekdays.

B. On-Site Building Specific Training shall include:

1. Explanation of drawings, operations and maintenance manuals
2. Walk-through of the job to locate control components
3. Operator workstation and peripherals
4. DDC controller and ASC/MSTP/IP Network Device operation/function
5. Operator control functions including graphic generation and field panel programming
6. Operation of portable operator's terminal
7. Explanation of adjustment, calibration and replacement procedures

**Appendix A-1: Submittal Completion Checklist**

# Submittals Completion Checklist

| | Description | Yes | No | Comments |
|---|---|---|---|---|
| Controls Drawings | | | | |
| Table of Contents | List of Contents within the submittals. | | | |
| Abbreviation Table | All Abbreviations used need to be listed here for easy reference | | | |
| Control Symbols Legend | List of all symbols used within the document and what they reference | | | |
| Master Bill of Materials | List of all parts used in project, to include at a minimum the Part Numbers, Manufacturer, Model Number, Device Tag, Device Range/Control as well as Control Type, General Description of items, and quantities used. Exclusions are Schedules (i.e. Valve/Damper etc.) | | | |
| Riser Diagrams | Provide detailed riser diagram of the complete system or building systems indicating all wiring types and protocols | | | |
| System Flow Diagrams | Provide schematic flow diagrams for each system being controlled. Illustrate all control points/objects labeled with point/object names shown on the controller termination drawing. The schematics will graphically show the location of all control devices in each system. Each System will also contain it's specific BOM with same specifications as the MBOM. Each system will also contain a Sequence of Operations for that specific system. | | | |
| System Wiring Diagrams | Provide a schematic ladder wiring diagram for each controlled system and control panel. Each schematic shall have all elements labeled. Illustrate specific termination details for all field equipment such as communication interfaces, VFD Interface I/O, Chiller Interface I/O, VRF Systems, RTU's FAS Systems, Generator Systems, Switch Gear Interfaces, Valves, Actuators and all end device terminations. | | | |

# Submittals Completion Checklist

| | Description | Yes | No | Comments |
|---|---|---|---|---|
| Controls Drawings (Cont.) | | | | |
| Transformer Loading | Provide a transformer loading calculation chart for all control transformers. Identify each load and its power consumption in this chart. This should be included on each control panel ladder diagram | | | |
| Panel Pictorial | Provide scaled panel pictorial drawings indicating all components being installed in each control panel. Terminals, power outlets, power supplies, relays, switches, interface boards, terminators, controllers, any panel mounted components. | | | |
| Schedules | | | | |
| Valve Schedule | Provide valve schedules indicating Valve Number, System/Function, Tag, Quantity, Flow Rate, Media Type, Body Type, Design Pressure Drop, Calculated CV, Actual CV, Pipe Size, Valve Body Size, Flow Characteristic, Close Off Pressure, Coil Pressure Drop, Fail Safe Mode, Control Signal, Model Number, Actuator Model Number, Power Requirements, NEMA Rating. All Valves installed on campus will be spring return to the appropriate position for the system unless approved in writing by Texas State University. | | | |
| Damper Schedule | Provide Damper Schedule indicating Damper Number, System/Function, Tag Quantity, Duct Dimensions, SQ/FT Area, Required Torque per SQ/FT, Actual Actuator Torque, Fail Safe Mode, Control Signal, Model Number, Actuator Model Number and Power Requirements. | | | |
| Air Flow Station Schedule | Provide Air Flow Station schedule indicating Flow Station Number, System/Function, Tag, Quantity, Duct Dimensions/Area, Control Signal, Model Number, Interface Protocol, and Power Requirements. | | | |

# Submittals Completion Checklist

| | Description | Yes | No | Comment |
|---|---|---|---|---|
| Schedules (Cont.) | | | | |
| Water Flow Meter Schedule | Provide water flow meter schedules indicating Flow Meter Number, System/Function, Tag, Quantity, Pipe Size, Pipe Schedule, Flow Rate, Control Signal, Model Number, Interface Protocol, any pertinent setup information required for maintenance, Power Requirements. | | | |
| Utility Metering Schedule | Provide utility metering schedule indicating (As Applicable) Meter Number, System/Function, Tag, Quantity, Pipe Size Pipe Schedule, Flow Rate, KW Rates, CT Sizes, Panel Locations, Circuit Numbers, or Metering Areas for GAS/City Water. For all utility metering provide Interface Control Signal, Model Number, Interface Protocol, and Power Requirements. Indicate who is providing the meter if it is provided by others. | | | |
| Terminal Box Schedule | Provide Terminal Box Schedule indicating Box Number, System/Function, Tag, Duct Inlet Dimensions, Minimum CFM, Maximum CFM, Fan Operation, Reheat Operation, Space Sensor Type, Controller Model Number, Interface Protocol, and Power Requirements. | | | |
| Product Data | | | | |
| | Provide Product Data Sheets/Cut Sheets for all products on the MBOM. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. | | | |

# Submittals Completion Checklist

| | Description | Yes | No | Comments |
|---|---|---|---|---|
| Integrations | | | | |
| | Products requiring integration to the controls system will supply, as part of their packages, catalog data sheets, wiring diagrams, and points lists to the Division 23 Contractor (when integrating with an Integrated Automation Facility Controls and Control System) for proper coordination of work. EACIS Contractor shall also include a complete points list/registry list of all points available to be integrated into the Automation Facility Controls. This contractor shall be responsible for As-Builts pertaining to overall Integrated Automation Facility Controls architecture and network diagrams. All As-Built drawings shall also be submitted to Planning, Construction, and Design as well as Technical Services. | | | |
| Training | | | | |
| | The Contractor shall provide a course outline and training manuals for all training classes at least three weeks prior to the first training class. Review and approval by Texas State University shall be completed at least one week prior to the first class. Contractor shall provide a qualified/competent trainer in the training course provided to Texas State University. | | | |

END OF SECTION 25 51 00