TABLE OF CONTENTS

DIVISION 13 – SPECIAL CONSTRUCTION (Not Used)

DIVISION 14 – CONVEYING EQUIPMENT (Not Used)

DIVISION 21 – FIRE SUPPRESSION (Not Used)

DIVISION 22 – PLUMBING (Not Used)

DIVISION 23 – HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

END OF TABLE OF CONTENTS

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SECTION 230923 – DIRECT DIGITAL CONTROL(DDC) SYSTEM FOR HVAC

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to DIVISION 23 for general provisions, installation requirements and additional HVAC equipment control information.

C. All electrical work shall be in accordance with Division 26 Specification Sections.

D. Related Sections include the following:

1. **Refer to Division 23 section 230593 FL - Testing, Adjusting, and Balancing for HVAC for additional work related to system testing and balancing.**
2. **Refer to Division 1 Section 019113 COMMISSIONING OF HVAC for work associated with HVAC system commissioning and 230800 - COMMISSIONING OF HVAC.**
3. **Refer to Division 23 Section 232113 HYDRONIC AND PLUMBING PIPING for water flow measuring devices that relates to this Section.**

1.2 SUMMARY

A. This Section includes all labor, materials, equipment, and service necessary for a complete and operating control system for all HVAC equipment including control of units not supplied with factory-wired controls and installation and wiring of loose controls shipped with equipment.

B. Furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing a high speed peer to peer network of interoperable Direct Digital Controls (DDC), Graphical User Interface (GUI) with color graphic displays available on at least 64 client computers, and electronic interfaces and actuation devices, as shown on the drawings and as described herein.

C. The new BAS system shall be fully compatible with the existing SI Wide Siemens Facility Management and Control System (FMCS). All new controls shall be fully accessible through the existing site-wide operator's terminals and FMCS Database Server located within the SI – NMNH Facility and Herndon Data Center (HDC). Division 23 contractor is responsible for determining compatibility prior to submitting bid.

D. Owner operates a FMCS manufactured by Siemens Apogee \ Desigo CC Building Automation System and services HVAC systems installed in previous projects. The intent of this specification is to extend and interoperate with the FMCS and to provide a peer-to-peer, networked control system for the control work that is part of this project. All components, software and operation shall be interoperable with the existing FMCS. The installed system will interface directly with the existing FMCS Database Server located within the SI - NMNH Facility and HDC. The existing software and database will be modified to accept the new equipment being installed under this project to maintain integrity for centralized scheduling, graphic trending, programming, alarming and remote notification. Personal Computer (PC) Desktop icons that "link" to a separate system are not acceptable. Any costs associated with connecting to the existing FMCS, including licensed software, programming, training, etc., shall be part of the controls contractor's bid. The contractor must demonstrate their ability to perform the integration to the existing FMCS prior to bid submittal acceptance. All systems as described in the sequence of operation will be shown via dynamic graphics with all pertinent system alarms for proper operation and maintenance. The use of separate PC workstations, gateways, metalinks, replacement of existing controllers and control devices and additional software graphic packages to accomplish this integration will not be accepted. *SI will not allow interphase with third party IP controllers within the SI.EDU Domain.*

1.3 DEFINITIONS

A. BAS: Building Automation System

B. Control Contractor: Contractor for this section

C. DDC: Direct Digital Control

D. I/O: Input/output

E. MS/TP: Master slave/token passing

F. NIST: National Institute of Standards and Technology

G. PC: Personal computer

H. PID: Proportional plus integral plus derivative

I. OWS: Operator Work Station

J. RTD: Resistance temperature detector

K. FMCS: Facility Management and Control System

L. ATC: Automatic Temperature Control

M. TAB: Testing Adjusting and Balancing

N. BACnet: Building Automation and Control Network

O. TCP: Transmission Communication Protocol

P. IP: Internet Protocol

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. **Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.**
2. **Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.**
3. **Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.**
4. **Object Scan: Transmit change of state and change of analog values to control units or work station within 6 seconds.**
5. **Alarm Response Time: Annunciate alarm at work station within 45 seconds. Multiple work stations must receive alarms within 5 seconds of each other.**
6. **Program Execution Frequency: Run capability of applications as often as five seconds but selected consistent with mechanical process under control.**
7. **Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values or update changes and outputs at least once per second. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within minimum tolerances as follows:**

    a. **Water Temperature: Plus (+) or minus (-) 1 deg. F**
    b. **Water Flow: + / - 5 percent of full scale**
    c. **Water Flow Meter: +/- 1 of full scale**
    d. **Water Pressure: + / - 2 percent of full scale**
    e. **Space Temperature: + / - 0.5 deg. F**
    f. **Ducted Air Temperature: + / - 0.5 deg. F**
    g. **Outside Air Temperature: + / - 0.5 deg. F**
    h. **Dew Point Temperature: + / - 3 deg. F**
    i. **Temperature Differential: + / - 0.25 deg. F**
    j. **Relative Humidity: Non-critical Areas + / - 2 percent**
    k. **Airflow (Pressurized Spaces): + / - 3 percent of full scale**
    l. **Airflow (Measuring Stations): + / - 2 percent of full scale**
    m. **Airflow (Terminal): + / - 10 percent of full scale**
    n. **Air Pressure (Space): + / - 0.01-inch wg.**
    o. **Air Pressure (Ducts): + / - 0.1-inch wg.**
    p. **Carbon Dioxide: + / - 50 ppm**
    q. **Electrical: + / - 5 percent of reading**

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. **DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator work station equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.**
2. **Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.**
3. **Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.**

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. **Bill of materials of equipment indicating quantity, manufacturer, and model number.**
2. **Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices. Contractor's detailed installation drawings will not be accepted in lieu of schematic flow diagrams.**
3. **Wiring Diagrams: Power, signal, and control wiring.**
4. **Details of control panel faces, including controls, instruments, and labeling.**
5. **Written description of sequence of operation.**
6. **Schedule of dampers including size, leakage, flow characteristics, and normal positions.**
7. **Schedule of valves including flow characteristics and normal positions.**
8. **All data sheets shall indicate accessories and options included.**
9. **DDC System Hardware:**
    a. **Wiring diagrams for control units with termination numbers.**
    b. **Schematic diagrams and floor plans for field sensors and control hardware.**
    c. **Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator work station and control unit locations.**
10. **Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.**
11. **Controlled Systems:**
    a. **Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.**
    b. **Written description of sequence of operation including schematic diagram.**
    c. **Points list.**

C. Software and Firmware Operational Documentation: Include the following:

1. **Software operating and upgrade manuals.**
2. **Program Software Backup: On a magnetic media or compact disc, complete with data files.**
3. **Device address list.**
4. **Printout of software application and graphic screens.**
5. **Software license required by and installed for DDC work stations and control systems.**

D. Qualification Data: For Installer and manufacturer.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. **Maintenance instructions and lists of spare parts for each type of control device.**
2. **Index sheet, listing contents in alphabetical order.**
3. **Manufacturer's equipment parts list of all functional components of the system, Auto-CAD disk of system schematics, including wiring diagrams.**
4. **Description of Sequence of Operations.**
5. **As-built interconnection wiring diagrams.**
6. **Operator's manuals.**
7. **Trunk cable schematic showing all remote electronic panel locations, and all trunk data wiring runs.**
8. **All commissioning documentation specified herein.**
9. **Copies of all graphic screens.**
10. **Keyboard illustrations and step-by-step procedures indexed for each operator function.**
11. **Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.**
12. **Calibration records and list of set points.**

G. Per submittal process, full point names must be submitted. All point names must adhere to SI point naming conventions for points, panels programs, equipment controllers and graphics.

H. Obtain latest revision of SI BAS naming convention from Smithsonian Facilities SED.

1. ***Smithsonian Point Naming.xlsx***

1.6 WARRANTY

A. Provide all services, materials and equipment necessary for the successful operation of the entire system for a period of one year after acceptance. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

B. The on-line support services shall allow the system supplier to remotely connect using Citrix using a token to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

C. If the problem cannot be resolved on-line by the local office, the national office of the building automation system manufacturer shall have the same capabilities for remote connection to the facility. If the problem cannot be resolved with on-line support services,

the system supplier shall dispatch the appropriate personnel to the job site to resolve the problem within 4 hours of the time that the problem is reported.

1.7 QUALITY ASSURANCE

A. Installer Qualifications

1. **Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.**
2. **The system shall be installed, commissioned, and serviced by manufacturer employed, factory trained personnel.**
3. **Installer of control system shall have a branch office within 50 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.**
4. **A minimum of 5 years' experience installing systems of similar complexity, size and scope.**

B. Manufacturer's Qualifications

1. **Acceptable Manufacturers:**

   a. **Siemens Industry, Inc., Beltsville Branch Office.**
   b. **Office #(301) 837-2600**

2. **At least 20 years' experience manufacturing control components and systems.**
3. **A single unified control software package with advanced graphics capabilities that has been in use for 10 or more years and is still fully supported (including revisions and upgrades).**

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

1.8 DELIVERY, STORAGE, AND HANDLING

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

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

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate location of control panels, dampers, valves, and devices such that clearance can be maintained for proper access to all components.

C. Coordinate equipment and wiring with DIVISION 26 requirements to achieve compatibility of communication interfaces, drives, motor starters and annunciation devices.

D. Coordinate equipment with DIVISION 28 to achieve compatibility with equipment that interfaces with Fire Alarm system.

E. Coordinate and assist Testing, Adjusting and Balancing (TAB) Contractor with proper set up and operation of HVAC Systems.

F. The minimum quantity of DDC/ATC panels is located on the contract documents. Provide additional panels as required. All panel locations must be approved by the Owner and Architect and coordinated with all trades prior to installation. If approval and/or coordination are not completed, then panels shall be relocated at no cost to owner.

G. Do not locate DDC panels above ceilings. Panels shall be located in mechanical rooms or in equipment systems rooms.

H. Automatic Temperature Control (ATC) valves and thermowells furnished by Control Contractor shall be installed by DIVISION 23 Contractor under the supervision of Control Contractor. All automatic control dampers shall be furnished by Control Contractor, and shall be installed by Contractor for Section 233300 FL - Air Duct Accessories under supervision of Control Contractor except where dampers are specified to be provided by unit manufacturer.

I. Combination fire/smoke and smoke dampers in ducts with electric motors will be provided by Contractor for Section 233000. Control Contractor shall wire electric motors.

J. Smoke detectors in ducts and at air handling units shall be wired into the Fire Alarm System by Division 28. Required power for those smoke detectors shall also be provided by Division 28. Provide wiring from smoke detectors/interface modules to respective air handling unit(s) and fan(s) for shutdown in the event of smoke conditions. Contractor for Section 23 30 00 will install detectors in ductwork where shown or where required.

K. Comply with all requirements of specification sections 230593 FL - Testing, Adjusting, and Balancing for HVAC and 019113 GENERAL COMMISSIONING REQUIREMENTS AND 230800 - COMMISSIONING OF HVAC. Furnish by contractors for specification sections 230593 and 019113 approved temperature control technical data and shop drawings, information relating to changes or revisions in work, and all other information required for proper balancing, adjusting and commissioning of systems.

L. Coordinate duct mounted airflow measuring station and static probes with specification section 233300 FL - Air Duct Accessories.

M. BAS Contractor shall be responsible to coordinate quantity and locations of wall and floor penetrations. Refer to DIVISION 07.

N. BAS Contractor provides all power wiring and devices required for electric/electronic operators/actuators.

O. BAS Contractor provides air volume (constant or variable) box controls. Furnish control valves for field installation and provide additional wiring as required for a complete installation.

P. All deviations from specifications shall be documented separately. Obtain approval for deviations prior to fabrication or installation. All issues shall be reviewed.

Q. All mechanical equipment sent with loose controls shall be mounted and wired by DIVISION 23.

R. BAS Contractor shall provide all "Blue" conduits, trays, etc. required for power and control wiring to his devices.

S. Control Contractor shall interlock fans or pumps through hard wiring where indicated on contract documents; software interlocks shall not be acceptable.

T. Provide communications interface with equipment furnished with factory microprocessor controls such as variable frequency drives, humidifier, etc. as required by the contract documents.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Acceptable Manufacturers: Provide system by the following:

1. **Installer/Manufacturer: Siemens Industry, Inc., Beltsville Branch Office.**
2. **OFFICE # (301) 837-2600.**

B. Provide a direct digital control (DDC) system consisting of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems and to perform functions as specified.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator work station permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

D. Provide extension of existing FMCS consisting of sensors, controllers, indicating devices, interface equipment, other apparatus, and accessories to operate mechanical equipment and to perform functions as specified.

E. Provide all materials and field work necessary for a complete system.

F. Provide electric operator for each damper and valve to be controlled, unless one is specified elsewhere.

G. Unless specified otherwise, provide proportional/integral/inverse derivative components for variable air volume controls, proportional/integral components for air handling unit discharge control, and fully proportional/integral components elsewhere.

H. Actuator motors that respond to incremental "pulse" signals or do not fail to the specified position shall be acceptable as indicated.

I. Provide all electrical wiring, communication cabling, relays or other devices for interlocking of equipment as described in Sequence of Operations or as shown on drawings.

J. DDC system shall be capable of operating in environmental conditions of 30 deg. F to 120 F and 10% RH to 90% RH non-condensing. Sensors and final control elements shall be capable of operating in environment in which they are installed.

K. Graphics: New global graphics to provide a user friendly interface to the new and existing detail graphics. Provide an overall riser diagram page which will allow instant access to new floor plan graphic pages, individual air handling units and central plants. An individual floor plan graphic will be provided for each floor of the building. The floor plan will show air handling zone layout and provide a link to the associated air handler graphic within each zone. Each space temperature available on the DDC system shall be interactively displayed on the floor plan. Provide sub-area graphics as required to fit all temperatures. All graphics that have a system or a piece of equipment shall have graphic links at the bottom linking to any system that is associated to that piece of equipment. Graphics shall use the standard backgrounds. All points shall be associated in the database to the graphic related to the piece of equipment. There will be a defined graphic for all FLN/MSTP devices. All points alarmed in the BAS not related to a fan, or other large system, shall be on a floor plan showing the location of the alarm.

L. All new hardware and software will be the latest model/version that is fully compatible with the existing FMCS.

M. Control System architecture and programing must be set up and configured in such a way so that network traffic associated with point / object sharing will be set up and configured to limit communication between panels to an absolute minimum.

N. All BACnet devices shall comply with SI BACnet configuration convention. This includes BACnet devices with or without a driver. The installer shall consult SI for the BACnet configuration convention to use.

2.2 DDC CONTROLLER INTEGRATION TO EXISTING BAS NETWORK

A. **Once the new DDC controllers are commissioned, the BAS contractor shall make the physical connection to the existing FMCS network.**

B. **Once the tie-in is complete, the BAS contractor shall confirm communication with the FMCS Database Server located in National Museum of Natural History (NMNH) and Herndon Data Center (HDC).**

C. **Upload all data to the server.**

D. **Create graphics that represent the new systems, including but not limited to AHU layouts, navigation, screens, and room graphics.**

E. **Map all BAS alarmed points into the existing Remote Notification (RENO) software installed on the FMCS Database Server.**

F. **All alarms are to be managed by the Control Contractor through project completion.**

G. **All control devices that control a piece of equipment energized by an Emergency Power source need to be energized by the corresponding Emergency Power source.**

H. **Database Clean Up: When points are deleted from the database. All references to those points need to be removed.**

I. **Reports need to be run to find all references. Items include but are not limited to graphics, reports, programs, etc. A copy of the reports must be made available for SI before, during and after replacement and new construction.**

J. **Make safe and or remove existing controls and appurtenances of equipment indicated to be demolished in the mechanical demolition drawings including but not limited to DDC controllers, sensors, transducers, devices, etc.**

2.3 ETHERNET COMMUNICATIONS AND EQUIPMENT

A. **The DDC Controllers shall communicate via TCP/IP over Ethernet. The BAS contractor shall furnish and install cables and operator workstation(s) connected to the SI.EDU WAN.**

1. **The BAS contractor shall design the network to accommodate all the DDC Controllers and PC's provided for the BAS system.**
2. **The BAS contractor shall coordinate: node names, IP addresses, access privileges, and system configuration with the owner prior to startup.**
3. **Provide modular 8-pin, Category 6 information outlets at all DDC controllers. The cable shall be terminated inside the field panel at the information outlet. A patch cable shall be provided to connect the field panel to the information outlet.**

    a. **Do not exceed 328 ft. from the field panel to the nearest hub, router, switch, or signal repeater. This shall include the length of the patch cable between the information outlet and the field panel.**
    b. **All new Ethernet BLN networks shall be a minimum of Category 6 certified 1Gb Base-T Ethernet cable, for future expansion.**
    c. **Use plenum-certified Ethernet cable when run through a plenum.**
    d. **Ethernet cable shall only be buried in an insulated electrical tunnel. Ethernet wiring is not certified for direct burial.**

2.4 DDC EQUIPMENT

A. **Operator Work Station: (Utilize the existing OWSs and Servers)**

1. **BAS Contractor to utilize the existing OWSs and Servers.**

2. Application Software: (Utilize the existing Siemens Insight Software)

a. **I/O capability from operator station.**
b. **System security for each operator via software password and access levels.**
c. **Automatic system diagnostics; monitor system and report failures.**
d. **Database creation and support.**
e. **Automatic and manual database save and restore.**
f. **Database Clean Up: When points are deleted from the database. All references to those points need to be removed. Reports need to be run to find all references. Items included but not limited to graphics, reports, programs, graphic trends, etc.**
g. **Custom graphics generation and graphics library of HVAC equipment and symbols.**
h. **Alarm processing, messages, and reactions.**
i. Trend logs (there should be no Change of Value (COV) of 0). Retrievable in spreadsheets, graphic display and database programs.

1) See trend set up requirements on the SI Point Naming Convention sheet.
2) Care must be made to select a reasonable number of samples in the panel and the server to prevent trend loss.

j. Alarm and event processing.
k. Object and property status and control.
l. Automatic restart of field equipment on restoration of power.
m. Data collection, reports, and logs. Include standard reports for the following:

1) Current values of all objects.
2) Current alarm summary.
3) Disabled objects.
4) Alarm lockout objects.
5) Logs.
6) Panel PPCL Report
7) Panel Point Log
8) Point Definition Report
9) FLN Diagnostics
10) Panel Configuration Report
11) Panel Point Address Report
12) Panel Point Definition Report
13) Panel Point Trend Report
14) TEC Initial Value Report

n. Custom report development.
o. Utility and weather reports.
p. Work station application editors for controllers and schedules.

3. Custom Application Software:

a. English language oriented.
b. Full-screen character editor/programming environment.
c. Support conditional statements.
d. Support floating-point arithmetic with mathematic functions.

e. Contains predefined time variables.

B. **Control Units: Modular, comprising processor board with programmable, nonvolatile, random access memory; local operator access and display panel; integral interface equipment; and backup power source.**

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator work station or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Application Programs:

a. Include control programs capable of performing functions as described in Sequence of Operations.
b. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
c. Remote communications.
d. Units of Measure: Inch-pound and SI (metric).

C. **Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.**

1. Units monitor or control each I/O point, process information, and download from or upload to operator work station or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications
b. Discrete/digital, analog, and pulse I/O
c. Monitoring, controlling, or addressing data points

D. **I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.**

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. **Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.**
6. **Universal I/Os: Provide software selectable binary or analog outputs.**

E. **Power Supplies: Transformers with Class 2 current-limiting type or over-current protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:**

1. **Output ripple of 5.0 mV maximum peak to peak.**
2. **Combined 1 percent line and load regulation with 100-μs response time for 50 percent load changes.**
3. **Built-in over-voltage and over-current protection and be able to withstand 150 percent overload for at least 3 seconds without failure.**

F. **Power Line Filtering: Internal or external transient voltage and surge suppression for work stations or controllers.**

2.5 DDC CONTROLLERS

A. **General**

1. **DDC controllers shall be capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.**
2. **Configuration: diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.**
3. **Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.**

B. **BAS system architecture to address DDC controller count to address the reliability of the facility project requirements. (At the Design Development submission AE shall define the level of reliability with System Engineering Division, and the building operators).**

C. **DDC controllers shall reside on a peer to peer network.**

1. **DDC controllers shall be a minimum of 16-bit stand-alone, multitasking, multiuser, real-time digital control processors.**
2. **Each primary networked DDC controller shall house a minimum of 32 MB RAM to support its own operating system, databases, and stand-alone software functions including:**

    a. **Control Processes**
    b. **Energy Management Applications.**
    c. **Alarm Management Applications including custom alarm messages for each level alarm for each point in the system.**

d. Historical/Trend data for points specified.
e. Custom Processes.
f. Operator I/O
g. Remote Communications

3. DDC controllers shall provide a communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
4. DDC controllers shall be provided with digital input and output LED status indication for visual confirmation of point conditions.
5. The operator shall have the ability to manually override automatic or centrally executed commands at the Networked DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
6. DDC Controllers shall be provided with communication ports for the control and monitoring of application specific controllers to coordinate control of major mechanical equipment with downstream terminal equipment.
7. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication to alert facility personnel of failure.
8. Controllers shall be provided with the capability to communicate TCP/IP directly over Ethernet, without the use of an external network interface card. Devices must:

a. Auto-sense 10/100 Mbps networks.
b. Receive an IP Address from a Dynamic Host configuration Protocol (DHCP) Server or be configured with a Fixed IP Address. (Owner shall provide IP addresses and relevant network information for each DDC controller provided under this specification.)
c. Resolve Name to IP Address for devices using a Domain Name Service (DNS) Server on the Ethernet network.

D. Each Application Specific Controller (ASC) shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multitasking, real-time digital control processor. Each ASC shall be capable of control of the terminal device independent of the manufacturer of the terminal device. All devices shall communicate using BACnet MSTP protocol or Siemens P1.

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

a. Air Volume Control Boxes (AVCB)
b. Unit Conditioners
c. Unit Ventilators
d. Fan Coil Units
e. Venturi Air Valves

2.6 CONTROL PANELS

A. Provide panels of unitized cabinet type for each system.

B. Enclosure: Fabricate panels from 12 gauge steel or aluminum with baked enamel finish, with hinged key lock door and UL listing as NEMA 1. All panel locks shall be keyed alike.

C. Mount all relays, clocks, switches, transmitters and controllers within cabinet. Mount temperature indicators, pressure gauges, pilot lights, pushbuttons and switches flush on cabinet face.

D. Provide engraved plastic nameplates for instruments and controls inside cabinet and on cabinet face. Nameplates shall be white with black center core.

E. All Non Siemens field panels or 3RD party devices will be located under the panel where the control is being performed.

2.7 FIELD HARDWARE PANELS (FHP)

A. Provide field hardware panel whenever interfaces between field equipment and DDC panels are necessary. Devices such as transducers (current to pressure, pressure to current), relays, contactors, and other devices shall be labeled for quick identification.

B. Provide power from the same source as DDC panels.

C. Provide plastic engraved nameplates for instruments and controls inside cabinet and on cabinet face.

2.8 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. **Wire: Twisted, shielded-pair cable.**
2. **Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.**
3. **Averaging Elements in AHU/Ducts: Minimum 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.**
4. **Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches**
5. **Room Sensor Cover Construction: Manufacturer's standard locking covers.**

    a. **Set-Point Adjustment: Exposed.**
    b. **Set-Point Indication: Exposed.**
    c. **Temperature Indication: Exposed Digital Display**
    d. **Color: Standard Orientation: Vertical.**
    e. **Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.**

C. RTDs and Transmitters:

1. **Wire: Twisted, shielded-pair cable.**
2. **Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.**
3. **Averaging Elements in Ducts: Minimum 8 feet in length; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.**
4. **Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches; length as required.**
5. **Room Sensor Cover Construction: Manufacturer's standard locking covers.**

    a. **Set-Point Adjustment: Exposed.**
    b. **Set-Point Indication: Exposed.**
    c. **Temperature Indication: Exposed Digital Display**
    d. **Color: Standard Orientation: Vertical.**
    e. **Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.**

D. Humidity Sensors: Bulk polymer sensor element. One percent full range with linear output; non-critical areas 2 percent full range with linear output. Due to the cost of the one percent sensors OPDC need to limit the use of sensors.

1. **Acceptable Manufacturers:**

    a. **ROTRONIC Instrument Corp.**
    b. **Vaisala**
    c. **General Eastern**

2. **Accuracy: non-critical areas 2 percent full range with linear output (all non “critical” areas or those designated by H or RH symbol/designation).**
3. **Room Sensor Range: 20 to 80 percent relative humidity.**
4. **Room Sensor Cover Construction: Manufacturer's standard locking covers.**

    a. **Set-Point Adjustment: Exposed**
    b. **Color: Standard.**
    c. **Orientation: Vertical**

5. **Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.**
6. **Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 32 to 120 deg. F**

E. Pressure Transmitters/Transducers: Duct sensors and Space sensors: With element guard and mounting plate, operational range of 0 to 100 percent relative humidity.

1. **Acceptable Manufacturers:**

    a. **Veltron (High Accuracy)**
    b. **Fisher-Rosemount (High Accuracy)**
    c. **Auto Tran (Mid Range)**
    d. **Setra (Low Range)**

2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.

a. High Accuracy Differential Pressure Transmitter: Shall be microprocessor based pressure and flow smart transmitters with automatic zeroing circuit.

1) Range: 0 to 0.1 inch wg.
2) Accuracy: 0.17 of natural span, including nonlinearity, hysteresis, dead band, non-repeatability.
3) Span Range: Calibrated span can be down ranged to 40 percent of natural span.
4) Transducer Response Time: 0.5 seconds to reach 98 percent of a step change.
5) Temperature Affect: Zero corrected by auto zero.
6) Mounting Position Affect: None.
7) Stability: Auto zeroing accuracies within 0.17 of calibrated span frequency every 1 to 24 hours on 1 hour intervals.
8) Temperature Limit: -20 to 120 deg. F
9) Humidity Limit: 0-90 percent RH.
10) Display: LCD data display and LED indicating lights.
11) Outputs: 4-20 mA.
12) Power Supply: 24 VAC/120 VAC.

b. Midrange Differential Pressure Transmitter: Shall be smart pressure transmitter.

1) Range: 0.1 to 3.0 inch wg.
2) Temperature Limits: -40 to 185 deg. F
3) Humidity Limits: 0-100 percent RH.
4) Stability: 5 year stability.
5) Outputs: 4-20 mA.

c. Low Range Differential Pressure Transmitter: Shall be zero maintenance pressure transducer.

1) Range: 0.1 to 5 inch wg.
2) Accuracy: + / - 1 percent at less than 1 inch wg.
3) Stability: Auto zero + / - 0.5 percent FSO over life of device.
4) Temperature Limits: 0 to 65 deg. F
5) Humidity Limits: 0-90 percent RH.
6) Outputs: 4-20 mA.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential; linear output 4 to 20 mA.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.9 STATUS SENSORS

A. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

B. Current Switches

1. **The current sensor shall be induce powered from the monitored load.**
2. **The current sensor shall provide on/off status indication of electrical loads from 1.5 to 200 amperes.**
3. **The selected switch shall match current VFD System output requirements.**
4. **The current sensor shall be capable of providing accurate status at temperatures from - 15° to 60°**
5. **The current sensor shall be isolated to 600 VAC rms.**
6. **The current sensor output shall be N.O. solid-state 1.0 ampere at 30 VAC/DC.**
7. **The current sensor shall be a self-gripping split-core type.**
8. **The current sensor shall detect drive belts slipping, breaking, or pump couplings shearing.**

C. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

D. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.10 GAS DETECTION EQUIPMENT

A. Acceptable Manufacturers:

1. **Honeywell International Inc.**
2. **MSA Canada Inc.**
3. **Siemens.**
4. **Vaisala.**

B. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg. F and calibrated for 0 to 2 percent with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

C. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of - 32 to + 1100 deg. F and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

2.11 THERMOSTATS

A. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

1. **Automatic switching from heating to cooling.**

2. **Preferential rate control to minimize overshoot and deviation from set point.**
3. **Set up for four separate temperatures per day.**
4. **Instant override of set point for continuous or timed period from 1 hour to 31 days.**
5. **Short-cycle protection.**
6. **Programming based on every day of week.**
7. **Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.**
8. **Battery replacement without program loss.**
9. **Thermostat display features include the following:**

    a. **Time of day**
    b. **Actual room temperature**
    c. **Programmed temperature**
    d. **Programmed time**
    e. **Duration of timed override**
    f. **Day of week**
    g. **System mode indications include "heating," "off," "fan auto," and "fan on"**

B. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg. F set-point range, and 2 deg. F maximum differential.

C. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg. F set-point range, and 2 deg. F maximum differential.

1. **Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.**
2. **Selector Switch: Integral, manual on-off-auto.**

D. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. **Bulbs in water lines with separate wells of same material as bulb.**
2. **Bulbs in air ducts with flanges and shields.**
3. **Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.**
4. **Scale settings and differential settings are clearly visible and adjustable from front of instrument.**
5. **On-Off Thermostat: With precision snap switches and with electrical ratings required by application.**
6. **Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.**

E. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set-point.

F. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod-and-tube, or averaging element.

G. Electric, Low-Limit Duct Thermostat (Low Temperature Limit Thermostat): Two sets of contacts, snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any incremental segment of capillary length is equal to or below set point.

1. **Capillary Length: Minimum 20 feet.**
2. **Quantity: One thermostat for every 20 sq. ft. of coil surface**

H. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig, and cast housing with position indicator and adjusting knob.

2.12 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. **Comply with requirements in Division 23 Section "Electrical Requirements for HVAC Equipment."**
2. **Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.**
3. **Non-Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.**
4. **Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.**
5. **Non-Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf. and breakaway torque of 300 in. x lbf.**
6. **Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.**

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. **Acceptable Manufacturers:**
   a. **Belimo Air Controls (USA), Inc.**
   b. **Siemens**
2. **Valves: Size for torque required for valve close off at maximum pump differential pressure.**
3. **Dampers: Size for running torque calculated as follows:**
   a. **Parallel-Blade Damper with Edge Seals: 7 inch-lb. /sq. ft. of damper.**

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb. /sq. ft. of damper.
c. Parallel-Blade Damper without Edge Seals: 4 inch-lb. /sq. ft. of damper.
d. Opposed-Blade Damper without Edge Seals: 3 inch-lb. /sq. ft. of damper.
e. Dampers with 2- to 3-Inch wg. of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers 3- to 4-Inch wg. of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: - 22 to + 122 deg. F
11. Temperature Rating (Smoke Dampers): - 22 to + 250 deg. F
12. Run Time: 30 seconds open, 30 seconds closed.
13. Run Time (Smoke Dampers): 12 seconds open, 5 seconds closed

2.13 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Hydronic system valves shall have the following characteristics:

1. NPS 2 and Smaller:

a. Globe Valve: Class 125 bronze body, bronze trim, stainless steel rising stem, renewable composition disc, and screwed ends with back seating capacity re-packable under pressure. Replaceable plugs and stainless-steel or brass seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
b. Ball Valve: Class 125 bronze body with full-port, chrome-plated bronze ball; TFE seats and packing; and 600-psig minimum CWP rating and blowout-proof stem. Threaded ends.

2. NPS 2-1/2 and Larger:

a. Globe Valve: Class 125 iron body, bronze trim, stainless steel rising stem, plug type disc, flanged ends, and renewable seat and disc. Replaceable plugs and stainless-steel or brass seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

b. Characterized Ball Valve for Large AC unit's Cooling Coils: 4" valve size, equal percentage flow characteristic, ANSI Class 125 Cast iron body, EPDM stem seal, PTFE seat, ANSI 125 flange pipe connection, EPDM O-ring, stainless

ball and stem and characterizing disc. Available manufacturer but not limited to Belimo B6400S-186.

1. **Two-way Modulating electronic valve actuator, Electronic Fail-Safe, 24V. Nominal voltage AC/DC 24 V, Power consumption in operation 12W, transformer sizing 21 VA (class 2 power source). Available manufacturer but not limited to Belimo GKRX24-MFT. Provide actuator compatible to existing Siemens DDC control.**

c. **Butterfly Valve: 150 psig WOG, bubble tight shutoff, 250°F continuous Butterfly type with one piece semi-steel body (split body design not acceptable), threaded lugs (same number of lugs as connecting flange), extended neck to suit insulation thickness, bronze disc, bronze bearings, stainless steel shaft and continuous retained EPDM resilient seat to provide end or isolation service without use of downstream flanges.**

3. **Sizing:**

a. **Two Position: Line size; ball or butterfly valve.**
b. **Two-Way Modulating: 8 -psig maximum pressure drop at design flow rate; Use Characterized Ball Valve for large AC unit's cooling coils.**
c. **Two -Way Modulating: 5 psig max pressure drop at design flow rate; globe or ball valve for other coils.**
d. **Three-Way Modulating: Line size; globe, ball or butterfly valve.**
e. **Differential Pressure: Typically 50% of pump head with full pump flow.**
f. **Valves Sized 6 inches and larger shall be butterfly type.**

4. **Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.**
5. **Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating equal to pump dead head (zero flow) pressure for two-way valves and 100 percent of pressure differential across valve for three-way valves.**
6. **One-third and two-thirds of total capacity is design and actual split will be the ratio of each valve's CV to the total CV.**

C. **Steam system valves shall have the following characteristics:**

1. **NPS 2 and Smaller:**

a. **Globe Valve: Class 125 bronze body, bronze trim, rising stainless steel stem, renewable composition disc, and screwed ends with back seating capacity re-packable under pressure. Replaceable plugs and stainless steel seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.**
b. **Ball Valve: Fed Spec WW-V-35C, Type II, Class C, D, Style 1 and 3, 2000 psi W.O.G., 250 psi saturated steam. Carbon steel body. Stainless steel trim, screwed ends, carbon filled, TFE seat and packing, blowout-proof stem.**

2. **NPS 2-1/2 and Larger:**

a. Globe Valve: Class 125 iron body, bronze trim, rising stainless steel stem, plug type disc, flanged ends, and renewable seat and disc. Replaceable plugs and stainless steel seats. Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

3. Sizing: For pressure drop based on the following services:

a. Two Position: Line Size; ball or globe valve.
b. Modulating 15-psig Steam: As indicated on drawings – 5-10 psig; globe valve.

4. Flow Characteristics: Modified linear characteristics.
5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

D. Terminal Unit Control Valves: Globe Valve, bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg. F
2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.14 DAMPERS

A. Acceptable Manufacturers:

1. Ruskin
2. Air Balance Inc.
3. Greenheck

B. Dampers: AMCA-rated, airfoil design; 0.108-inch minimum thick, galvanized steel or 0.125- inch minimum thick, extruded aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel or extruded aluminum with maximum blade width of 6 inches and length of 48 inches. Dampers installed in stainless steel ductwork shall be completely constructed of stainless steel. All shafts penetrating the duct shall be provided with sealed bearings to prvent air leakage around the shaft penetrations.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From -40 to +200 deg. F
3. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg. when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

C. Provide parallel type blades for mixing applications and opposed blade dampers for all other reasons.

D. Damper End Switches: Whisker type end switches.

2.15 WATER FLOW METER

A. **Acceptable Manufacturers: Company manufacturing water flow measuring station shall have a minimum of five years' experience producing products specified.**

1. Onicon

2. Siemens

3. Spirax Sarco

4. Rosemount

5. Neptune

6. Badger

B. **Water Flow Meter: Onicon, Model F-3500.**

1. Electromagnetic insertion type flow meter, wetted part of meter constructed from stainless steel, average velocity readings from two sets of diametrically opposed electrodes, accuracy shall be within +/-1% of flow rate from 2-20 ft/s, overall turndown exceeds 100:1, output signal consists of high resolution frequency to use in thermal energy meter, analog and scalable dry contact for totalization.

2.16 AIR FLOW MEASURING STATION

A. Acceptable Manufacturers: Company manufacturing air flow measuring station shall have a minimum of five years' experience producing products specified.

1. Ebtron: Thermal dispersion airflow measurement technology.

B. Fan Inlet Airflow Station:

1. Furnish fan inlet airflow traverse probes (bellmouth); multi-point, self-averaging thermal dispersion airflow measurement technology.
2. Piezometer ring shall not be acceptable.
3. Assembly shall product minimum accuracy of 3% of actual flow without significantly impacting fan performance or contributing to fan generated noise.
4. *Thermal Dispersion Airflow Measurement Technology: Ebtron Model GTC108-F*

a. A single manufacturer shall provide both the airflow/temperature measuring probes and a compatible transmitter at a given measurement location.
b. Each sensor housing shall utilize two hermetically sealed, bead in glass thermistor probes to determine airflow rate and ambient temperature

c. Standard size ranges: 11 inches to 64 inches with adjustable mounting brackets

d. Construction:

1) Sensor Mounting Block and Mounting Feet: 304 stainless steel

2) Rod Construction: Adjustable length cadmium plated rods

e. Transmitter:

1) The transmitter shall be capable of communicating with the BAS using a linear output signal, field selectable fuse protected and isolated, 0-10 VDC and 4-20 mA (4-wire).

C. Duct Airflow Probe: *Ebtron Model GTC116-P*

1. Traverse probe shall be extruded aluminum construction furnished with mounting plate, gasket, and signal fittings suitable for HVAC duct installation.

2. Probes shall be AMCA certified and capable of measuring the airflow rates within an accuracy of + / - 2 percent without the use of correction factors.

3. The maximum allowable pressure drop caused by the probes shall not exceed 0.025 inch at 2000 FPM.

2.17 DUCT STATIC PROBE

A. Furnish duct static pressure probe and place for static pressure sensing 2/3 of way downstream in system ductwork. Coordinate final location of sensor with Engineer.

B. Duct Airflow Station:

1. Fabricate of galvanized steel with flanges, size for duct in which mounted. Maximum pressure loss through station of 0.08 inches water gauge at 1500 fpm. Sound level within the duct shall not be amplified nor shall additional sound be generated by air measuring station.

2. Station shall have accuracy of 2% from 960 fpm to 4000 fpm and

3. Identify by model number, size, area and specified air flow capacity.

C. Construct with multiple static pressure sensors located along exterior surface of cylindrical probe, of extruded aluminum and (except for 3/4 inch dia. probes with lengths of 24 inches or less) complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. Produce steady, non-pulsating signal of standard static pressure, without need for correction factors, with instrument accuracy of 0.5%.

2.18 RELAYS AND CONTACTORS

A. General

1. **Relays and contactors shall be manufactured and tested according to the latest applicable standards of the following agencies:**

    a. **NFPA 70 – National Electrical Code.**
    b. **CSA C22.2 No. 14, Industrial Control Equipment.**
    c. **NEMA ICS 2 – Controllers, Contactors and Overload Relays.**
    d. **NEMA ICS 5 – Control Circuit and Pilot Devices.**
    e. **NEMA ICS 6 – Enclosures for Industrial Controls and Systems.**
    f. **UL 508, Industrial Control Equipment.**

2. **Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in controller and if necessary, apply temporary heat where required to obtain suitable service conditions.**
3. **All contactors and relays shall be rated for continuous duty and for a minimum of 100,000 full load activations.**
4. **Relay and contactors shall be UL and cUL listed power control devices with a minimum AIC rating of 10,000A.**
5. **Relays and contactors shall be provided in dust proof enclosures.**

B. Contactors

1. **All contactors shall be NEMA rated general purpose contactors for single phase induction type motors rated up to 5 Hp @ 575 VAC.**
2. **NEMA ICS 2, AC general purpose Class A magnetic contactor for induction motors rated in horsepower. NOTE: Half sizes are not referenced in NEMA standards, but conform to specified regulatory requirements and shall be utilized where possible to reduce costs.**
3. **Provide two pole contactors for 2-wire loads and three pole for all 3-wire loads.**
4. **NEMA ICS 2, AC general purpose Class A magnetic contactor for induction motors rated in horsepower. NOTE: Half sizes are not referenced in NEMA standards, but conform to specified regulatory requirements and shall be utilized where possible to reduce costs.**
5. **Wiring: Straight-through wiring with all terminals clearly marked.**
6. **Enclosure: NEMA ICS 6, Type as required to meet conditions of installation.**
7. **Auxiliary Contacts: NEMA ICS 5 rated A600, two normally open and two normally closed contacts in addition to the seal-in contact.**
8. **Control Power Transformers: Provide fused primary and secondary and connect non-fused leg of secondary to enclosure.**
9. **Provide NEMA ICS 5 cover-mounted type or flange-mounted type indicating light based upon enclosure selection. Contacts shall be rated NEMA B600 for cover-mounted devices and NEMA A600 for flange-mounted 30mm devices.**

C. Relays

1. **Relays to be industrial grade DPDT or DP4T with LED status indicator.**
2. **Relay contacts to be NEMA rated for single phase induction type motors up to ½ HP @ 277V and for general use up to 10A @ 277V.**
3. **Relays located near control panels shall be plug-in type and shall be consolidated in a Field Hardware Panel. Relays shall be replaceable without tools or removing wiring.**
4. **Enclosed type relays may be used for terminal control applications.**

PART 3 – EXECUTION

3.1 EXAMINATION

A. **Verify that power supply is available to control units and operator work station.**

B. **Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.**

3.2 INSTALLATION

A. **General**

1. **Install software in control units and operator work station(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.**
2. **Connect and configure equipment and software to achieve sequence of operation specified.**
3. **Furnish automatic control dampers to Division 23 Section "Duct and Duct Accessories" for installation.**
4. **Install damper motors on outside of duct in tempered areas, not in locations exposed directly to outdoor temperatures.**
5. **Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."**
6. **Coordinate location of hydronic instrument wells, valves, and other accessories installed by Division 23 Section "Hydronic Piping Systems."**
7. **Coordinate location of steam and condensate instrument wells, valves, and other accessories installed by Division 23 Section "Steam and Condensate Piping Systems."**

B. **Thermostats and Temperature Sensors**

1. **Verify location of thermostats and/or temperature sensors where shown on drawings and room interior elevations. Coordinate location with other wall mounted devices.**
2. **Install space thermostats and/or temperature sensors 48 inches above finished floor.**
3. **Provide insulation pads for thermostats and/or temperature sensors mounted on exterior walls and columns.**
4. **Install averaging elements in ducts and plenums in serpentine, crossing or zigzag pattern across the area of duct or plenum in order to sense true average temperature. Secure averaging elements in such a manner as to prevent vibration from causing element fatigue.**
5. **Secure duct mounted sensors to ductwork in a vibration free area.**
6. **Furnish thermal wells for sensors to be installed in piping. Furnish extension necks where installed in insulated piping. Material for wells shall be compatible with material of piping where installed.**

C. **Humidity Sensors**

1. **Verify location of humidistats and/or humidity sensors where shown on drawings and room interior elevations. Coordinate location with other wall mounted devices.**
2. **Install space humidistats and/or humidity sensors 48 inches above finished floor.**

3. Secure duct mounted sensors to ductwork in a vibration free area.

D. **Low Temperature Limit Thermostats**

1. Install sensing element serpentine across coil to provide full coil sensing.
2. Set point shall be adjustable. Initial setting at 35 deg. F. Wired to stop fan and alarm DDC system
3. Provide a low temperature limit thermostat for every 20 square feet of coil area.
4. Install on entering side of cooling coil unless otherwise shown elsewhere on the drawings.

E. **Control Valves**

1. Tag each valve with brass or aluminum tag with corresponding number on control drawings. Tag shall identify valve number and be attached to valve with non-ferrous metal chain.

F. **Control Dampers**

1. Verify size and locations of control dampers with Division 23 Contractor prior to fabrication. Locations of dampers shall be reviewed to insure that maximum velocity rating is not exceeded.

G. **Water Flow Meter**

1. Verify size and locations of water flow meter with Division 23 Contractor prior to fabrication. Locations of water flow meter shall be reviewed to insure adequate straight run distances are provided.

H. **Airflow Measuring Stations**

1. Verify size and locations of duct mounted airflow stations with Division 23 Contractor prior to fabrication. Locations of airflow stations shall be reviewed to insure adequate straight run distances are provided.

I. **Control Panels**

1. Mount control panels adjacent to associated equipment either on walls or freestanding on steel supports. Mounting on ductwork or air handling units will not be permitted. Panels shall be free from vibration.
2. Panels shall be securely mounted with vertical and lateral bracing.

J. **Current Switches**

1. Shall be installed such that core is securely in place.
2. Shall be adjusted such that calibration trip point will detect drive belts slipping, breaking, or pump coupling shear.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. **Provide signal and power wiring to all panels and devices furnished under the contract. Provide signal and safety device wiring to all equipment controlled under this contract.**

B. **Provide all interlock wiring between equipment being sequenced as required to accomplish the sequence of operations, which shall include supply and return air fan arrays, exhaust fans, coil circulating pumps, humidifier control panels, flow switches, etc.**

C. **Mount and wire all loose control components provided with packaged equipment.**

D. **Provide all required power wiring and conduit for all panels furnished by the contractor for the project. Provide plenum rated cabling in the ceiling space for all work related to pneumatic control upgrade work. All BAS panels serving equipment connected to emergency power shall be circuited to the nearest emergency essential equipment panel. All other BAS panels shall be circuited to nearest normal power panel. Provide 20A single pole circuit breakers where required. Refer to electrical documents to ascertain exact location of nearest panel boards. Multiple panels may use same circuit within the electrical limitations. Indicate panel board name and circuit number for each panel on shop drawings.**

E. **Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."**

F. **Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."**

G. **Install hangers and support according to Division 26 Section “Hangers and Supports for Electrical Systems.**

H. **Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.**
   1. **Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.**

3.4 FIELD QUALITY CONTROL

A. **Manufacturer's Field Service: Engage a BAS factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.**

B. **Perform the following field tests and inspections and prepare test reports:**
   1. **Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.**
   2. **Test and adjust controls and safeties.**
   3. **Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.**
   4. **Test each point through its full operating range to verify that safety and operating control set points are as required.**
   5. **Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.**

6. **Test each system for compliance with sequence of operation.**
7. **Test software and hardware interlocks.**

C. **DDC Verification by BAS Contractor:**
1. **Verify that instruments are installed before calibration, testing, and loop or leak checks.**
2. **Check instruments for proper location and accessibility.**
3. **Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.**
4. **Check instrument tubing for proper fittings, slope, material, and support.**
5. **Check installation of air supply for each instrument.**
6. **Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.**
7. **Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.**
8. **Check temperature instruments and material and length of sensing elements.**
9. **Check control valves. Verify that they are in correct direction.**
10. **Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.**
11. **Check DDC system as follows:**
    a. **Verify that DDC controller power supply is from emergency power supply, if applicable.**
    b. **Verify that wires at control panels are tagged with their service designation and approved tagging system.**
    c. **Verify that spare I/O capacity has been provided.**
    d. **Verify that DDC controllers are protected from power supply surges.**

D. **Replace damaged or malfunctioning controls and equipment and repeat testing procedures.**

3.5 TESTING, ADJUSTING AND BALANCING

A. **Testing, adjusting and balancing of air and water systems will be provided under 23 section 230593 FL - Testing, Adjusting, and Balancing for HVAC.**

B. **Cooperate with testing, adjusting and balancing Contractor in coordination and scheduling of testing, balancing and adjusting work, as well as determining appropriate set point adjustments required for proper system operation.**

C. **Provide notice upon completion of all preparatory work and all initial operational testing required as part the Work. Perform additional operational testing on equipment, or systems, as directed and to extent and for duration deemed necessary, to demonstrate that systems are performing properly and delivering quantities in accordance with the requirements of the Contract Documents.**

D. **BAS Contractor shall set up and calibrate the mass flow control devices to the design contract values. BAS Contractor shall adjust the AVCB control so that final setup does not deviate more than + / - 5 percent from the design value.**

E. **BAS Contractor shall obtain static pressure readings from TAB Contractor at the various points in the system for programming and tuning final set point conditions.**

3.6 COMMISSIONING

A. **Commissioning will be provided as specified in 019113 COMMISSIONING OF HVAC for work associated with HVAC system commissioning and 230800 - COMMISSIONING OF HVAC . All contractors and subcontractors of the various sections of this specification shall cooperate and participate in the commissioning work in accordance with these requirements.**

B. **Ensure participation of major equipment manufacturers or their representatives.**

C. **Equipment and systems/subsystems installed under this section are expected to be in full compliance with the design intent at time of commissioning. Notify the Commissioning Agent when any specific piece of equipment or specific system/subsystem is ready for commissioning. Be prepared to demonstrate system readiness.**

3.7 DEMONSTRATION

A. **Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training." Provide 5 days of project specific DDC training to focus on the AHUs associated sequences of operations & control devices while the generic DDC training is not required.**

B. **Upon completion of all work and tests, operate systems for a sufficient length of time to demonstrate to Owner, mode of operation and definitively determine whether the system as a whole is in first class working condition. Before systems are turned over to Owner, a final demonstration test of 48 continuous hours, during which systems shall operate without adjustment, shall be performed.**

C. **Before installation is accepted, provide certification to Owner and Architect that control system and equipment have been inspected and found to be properly installed and functioning satisfactorily.**

END OF SECTION 230923

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