**Invitation for Bids for the Brownsville Police Administration Building Air Cooled Chiller Unit Replacement and Building Temperature Control System**

**BID # ACC-42-0719** **July 18, 2019 at 3:00 P.M**

## City of Brownsville
## Purchasing Department

## ADDENDUM # 1

## Invitation for bids for the Brownsville Police Department Building Air Cooled Chiller Unit Replacement and Building Temperature Control System

## Date Issued: July 15, 2019

### ACKNOWLEDGEMENT OF RECEIPT

**Please fax this page upon receipt**

Please fill in the requested information below as acknowledgment that *you have received the* Addendum noted above. If your firm is interested in participating, this sheet must be completed and returned or faxed to:

Mr. Roberto C. Luna, Jr.
Purchasing Director - City of Brownsville - P.O. Box 911
City Hall 1001 E. Elizabeth St. 1ST FLOOR Suite No. 101
Brownsville, Texas 78520
Phone: (956) 548-6087 Fax: (956) 546-2711
Email: purchasing@cob.us

Name of Firm: _____

Address: _____

City, State _____ Zip:_____

Telephone Number: _____ Fax Number: _____

E-mail:_____

( ___ ) **YES,** Our Company does have an interest in responding.
( ___ ) **NO,** Our Company does not have an interest in responding.

Name: (Print) _____

Title: _____

Signature: _____

Date: _____

**Invitation for Bids for the Brownsville Police Administration Building Air Cooled Chiller Unit Replacement and Building Temperature Control System**

**BID # ACC-42-0719** **July 18, 2019 at 3:00 P.M**

***ADDENDA*:** The undersigned hereby acknowledges receipt of the following addenda to the Specifications, all of the provisions and requirements of which Addenda have been taken into consideration in the preparation of the foregoing proposal.

## Clarifications/Additional Information/Changes to the Original bid package:

1. **Request for additional information/Addendum #1 Narrative (See Attached documents)**

_____
(Name of Bidder)

_____
(Signature)

_____
(Print)

_____
Date)

**END OF ADDENDUM # 1**

5000 West Military, Ste 100
McAllen, Texas 78503
(956) 664-0286
Fax (956) 664-0282

# REQUEST FOR INFORMATION

| | | | |
|---|---|---|---|
| **To:** | Alfonso Mendoza, City of Brownsville | **Date:** | July 15, 2019 |
| **From:** | Halff Associates, Inc. | **AVO:** | 33191 **RFI No.:** 1 |
| **Email:** | rtijerina@halff.com | **Project:** | BPD Administration Building Air Cooled Chiller Unit Replacement and Temperature Control System |
| **Subject:** | Johnson Controls Questions and Clarification Request | | |

☐ Letter Dated: _____ ☒ E-Mail Dated: **07-12-2019**

☐ Phone Call Dated: _____ ☐ Fax Dated: _____

This confirms and records a request for information. Unless notified in writing within three days of date noted above, it is agreed that a response generated from the request shall be provided to this office within five days.

**REQUEST:**

Good morning, this email is a request for information with questions & clarifications request.

**Building Automation Questions**

1) On page 186 we have attached a screen shot are all those operator interfaces necessary? Typically we provide a work station & maybe a lap top.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC 230923 - 18

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2) On page 183 What exactly does this detail mean on item #2 we have attached a screen shot below.

2.1 DDC SYSTEM MANUFACTURERS
1. Johnson Controls, Inc.
2. TraneRetain first two subparagraphs below for pneumatic control systems only.Tran

3) Just for clarification page 169 1.1 Summary: Will All control valves will stay existing, all mechanical dampers & actuators will remain existing?

4) Throughout the document there is mention of a "Server" page 183 is an example we have attached a screen shot of that paragraph. Can you please confirm if a hardware data server or virtual server is required for this system normally a workstation is sufficient & the engines retain sufficient space for data? Typically with a system of this size where its 1 small building servers are not necessary. Please confirm.

2.3 WEB ACCESS

A. DDC system shall be web based or web compatible.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on server thin-client architecture, designe around open standards of web technology. DDC system server shall be accesse using a web browser over DDC system network, using Owner's LAN, an remotely over Internet[ through Owner's LAN].

b. Intent of thin-client architecture is to provide operators complete access to DD system via a web browser. No special software other than a web browser shall b required to access graphics, point displays, and trends; to configure trends, points and controllers; and to edit programming.

c. web access shall be password protected.

**HVAC Mechanical Questions**

1) Just for confirmation purposes in addition to the factory Dip e-coating the additional field coating on the condenser cabinet the screen shot of the detail on page 290 is listed below, please confirm that is a necessary requirement?

3. PROVIDE FACTORY FULL DIP E–COATING ON CONDENSER COILS AND FIELD APPLIED COATING ON CONDENSER CABINET RATED TO 6,000 HOURS SALT SPRAY TESTING F

2) Alternate 1 identifies replacing all pipe with still being able to keep the cooling system running, the question is will we be allowed to shut the system down completely on a weekend to install the necessary portable cooling taps for temporary cooling? It is the only way possible in order to be able to accommodate this alternate.

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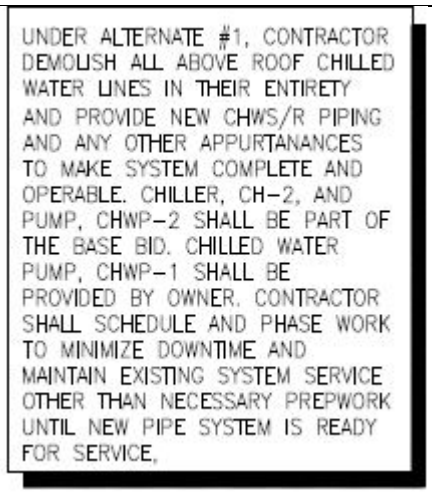


3) If the plans & specifications change or are modified based on RFI questions & confirmations will an extension be offered to allow for extra time to estimate any additional changes to the project?

.

**ANSWER:**

**Building Automation Questions**

Item 1) Building Automation Questions, provide desktop workstation with hardwired connection through LAN port. In addition to workstation, provide remote connection through web access.

Item 2) DDC System Manufacturers, remove “first two subparagraphs below for pneumatic control system only Tran”. Should read 1. Johnson Controls, Inc. and 2. Trane.

Item 3) As noted in Section 230923 1.1 Summary A., existing valve actuators and dampers shall remain, if identified as bad or defective a replacement shall be quoted separately, and actuators/dampers shall be replaced.

Item 4) Server and/or virtual server shall not be required. DDC system software shall be based on the supervisory controller.

**HVAC Mechanical Questions**

Item 1) As noted in chiller schedule, provide coil coating and provide condenser cabinet /chassis coating.

Item 2) It is understood and acceptable that the system will need to be shutdown to complete Alternate 1. As noted on sheet MD1.01 and M1.02, Contractor shall schedule and phase work to minimize downtime. Schedule shall be coordinated with owner prior to commencement of demolition. Coordinate with owner seven (7) days minimum in advance of system shutdown.

Item 3) Plans and specifications have not been changed drastically due to this RFI. There is reasonable time to estimate the changes. An extension will not be provided.

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Answered By: Robert Tijerina, PE .

Copies: ☐ File ☐ Owner ☐ Owner ☐ Other:

Attachments: _____

HALFF

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# ADDENDUM 1 NARRATIVE

| | | | |
|---|---|---|---|
| **To:** | Alfonzo Mendoza, City of Brownsville | **Date:** | 7/15/2019 |
| **From:** | Robert Tijerina, PE | **AVO:** | 33191 |
| **Email:** | rtijerina@hallf.com | **Project:** | BPD Administration Building Air Cooled Chiller Unit Replacement and Temperature Control System |
| **Subject:** | Addendum No. 1 | | |


**MECHANICAL**

The following are clarification notes made to the plans and specifications. The changes are outlined by item number, as well as plan sheet number. The contractor shall replace original issued sheet with the Addendum 1 sheets in their entirety.

Specifications:

ITEM 1. Section 230923 – Direct Digital Control (DDC) System for HVAC
- a. Removed requirements of server and virtual server from specifications. DDC system software shall be based on supervisory controller(s).

ITEM 2. Section 230923 – Direct Digital Control (DDC) System for HVAC
- a. From Section 2.1 DDC System Manufacturers, fixed typo after Trane. Section 2.1 shall read, "1. Johnson Controls, Inc.
  2. Trane"

ITEM 3. Section 230923 – Direct Digital Control (DDC) System for HVAC
- a. From Section 2.6 DDC System Operator Interfaces, removed Item 2., Item 3., and Item 4. from options. DDC system shall be accessed through desktop workstation with hardwired connection through LAN port and remote connection through web access. Other means of access are not required.

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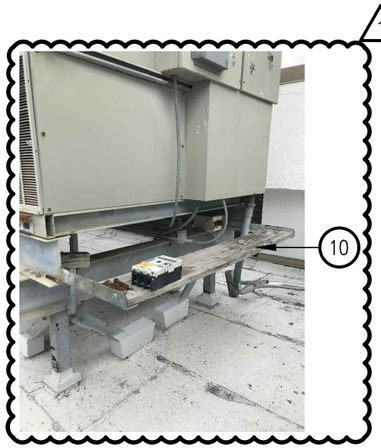
Drawings:

ITEM 1. Sheet MD1.01.
a. Addition of Key Note #10 to replace existing wood platform with new galvanized steel grate.



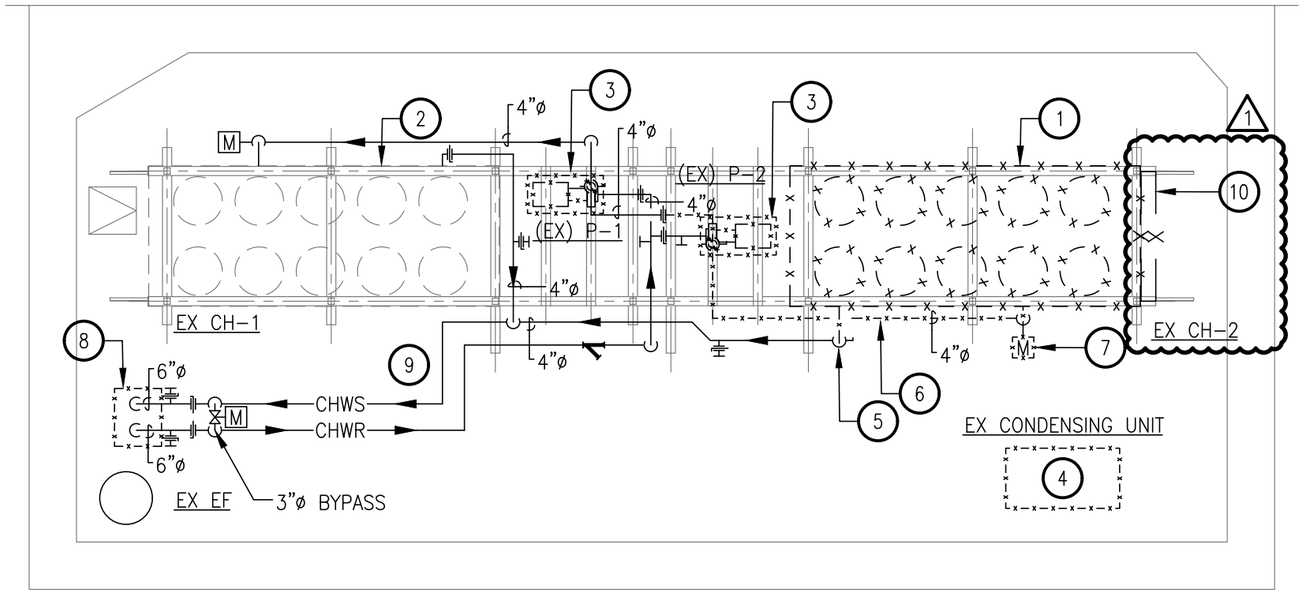

02 PHOTO PLATE
N.T.S.

DEMOLITION WORK SHALL BE ACCOMPLISHED/PHASE IN A MANNER THAT ALLOWS THE POLICE STATION TO MAINTAIN ITS NORMAL OPERATION. SCHEDULE SHALL BE COORDINATED WITH OWNER PRIOR TO COMMENCEMENT OF DEMOLITION. ANY WORK PHASE THAT REQUIRES CHILLED WATER SYSTEM UNAVAILABILITY SHALL BE COORDINATED WITH OWNER SEVEN (7) DAYS MINIMUM IN ADVANCE OF SHUTDOWN.

## LEGEND

— X — X — EXISTING MECHANICAL TO BE DEMOLISHED

——————— EXISTING MECHANICAL TO REMAIN




# GENERAL DEMOLITION NOTES:

A. REFER TO M0.01 FOR GENERAL MECHANICAL NOTES.

# KEY NOTES: (#)

1. CONTRACTOR SHALL DEMOLISH EXISTING CHILLER IN ITS ENTIRETY AND DISPOSE OF PROPERLY. CONTRACTOR SHALL DISCONNECT ELECTRICAL, CHILLED WATER CONNECTIONS, AND BUILDING AUTOMATION WIRING.
2. EXISTING CHILLER TO REMAIN.
3. CONTRACTOR SHALL DEMOLISH EXISTING CHILLED WATER PUMP.
4. DEMOLISH EXISTING CONDENSING UNIT. REFRIGERANT PIPING SHALL BE CAPPED AND ABANDONED.
5. EXISTING CHILLED WATER SUPPLY PIPE TO BE REMOVED IN ITS ENTIRETY TO POINT SHOWN. CONTRACTOR TO REMOVE CHILLED WATER ACCESSORIES TO INCLUDE FLOW SWITCH, PRESSURE SENSOR, THERMOMETER, AND CHILLED WATER PIPING.
6. EXISTING CHILLED WATER RETURN PIPE TO BE REMOVED IN ITS ENTIRETY TO POINT SHOWN. CONTRACTOR TO REMOVE CHILLED WATER ACCESSORIES TO INCLUDE, TEMPERATURE SENSOR AND CHILLED WATER VALVE.
7. 2-WAY MOTOR OPERATED CONTROL VALVE SHALL BE SALVAGED AND CLEANED FOR RE-USE.
8. DEMOLISH EXISTING PITCHPAN. CURB SHALL REMAIN FOR RE-USE.
9. ANY ROOF SUPPORTS SERVING EXISTING EQUIPMENT SCHEDULED FOR DEMOLITION AND NOT SERVING OTHER UTILITIES (OR PLANNED FOR SERVICE WITH NEW UTILITIES) SHALL BE REMOVED.
10. CONTRACTOR SHALL DEMOLISH EXISTING WOOD PLATFORM AND PROVIDE NEW PLATFORM, WELDED TO EXISTING FRAME, EQUAL TO McNICHOLS GALVANIZED STEEL GRATE WITH MINIMUM 40PSF AT 6-FOOT SPAN. CONTRACTOR TO PROPOSE SELECTED GRATE PROFILE TO OWNER/ENGINEER FOR APPROVAL.

1

01 MECHANICAL DEMOLITION ENLARGED PLAN
SCALE: 1/8" = 1'-0"

HALFF
5000 WEST MILITARY, SUITE 100
McALLEN, TEXAS 78503
TEL (956) 664-0288
FAX (956) 664-0282
TBPE FIRM #F-312

BROWNSVILLE POLICE STATION
BPD ADMINISTRATION BUILDING AIR COOLED CHILLER UNIT REPLACEMENT AND BLDG TEMPERATURE CONTROL
600 E. JACKSON ST.

STATE OF TEXAS
ROBERTO H. TIJERINA
121946
LICENSED
PROFESSIONAL ENGINEER
6/19/2019

| | |
|---|---|
| Project No.: | 33191.008 |
| Issued: | 6/19/19 |
| Drawn By: | MH |
| Checked By: | RT |
| Scale: | AS NOTED |

Sheet Title

MECHANICAL DEMOLITION ENLARGED PLAN

MD1.01
Sheet Number

# SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Currently, an existing Trane DDC system is installed and operating to control the equipment at the City of Brownsville Police Station. The new DDC system shall be web-based and utilize the BACnet protocol. This will grant remote access to the building's HVAC automation system from any computer on the Brownsville Police Department network. New software will allow facility to accommodate the existing equipment with latest generation hardware, software and graphics. Newly upgraded system will be capable of supporting all future expansions and controller replacements. All Trane zone sensors shall be removed and replaced with new BACnet compatible network temperature zone sensors. Communication wire and cable shall be replaced existing raceways may be reused. Existing valves to remain, if identified as bad or defective a replacement shall be quoted separately, and valve actuators shall be replaced. Existing dampers to remain, if identified bad or defective a replacement shall be quoted separately, and actuators shall be replaced. Provide new relays and switches and any other appurtenance to make system compete and operable. The sequence of operations for this facility shall not be altered and shall match the existing system. As a minimum, the new DDC control system shall control and monitor the following equipment:
-2 Chillers
-2 Chilled Water Pumps
-8 Air Handlers
12 Fan Coil units
4 DX Split units
1 Computer Room Unit
Exhaust fans

B. Performance Requirements.
   1. It is the intent of this specification to provide general requirements for the replacement of the existing DDC system with a new fully functional DDC building automation system. It shall be the responsibility of the contractor to review the existing conditions, function of the existing equipment and match the existing sequence of operations of the HVAC equipment for a fully functional system. Contractor shall provide all labor, materials, hardware and equipment necessary for a complete operational building automation system.
   2. Site Visit.
      a. It shall be **mandatory** that any vendor interested in providing a bid related to the building automation system shall visit the site prior to bid in order to become familiar with the specific mechanical systems, quantities and building requirements.
      b. Vendors who fail to do so shall be disqualified from bid.

C. Section Includes:

   1. DDC system for monitoring and controlling of HVAC systems.

D. Related Requirements:
   1. Communications Cabling:
   2. Raceways:
      a. Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
   3. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.2 DEFINITIONS

A. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

B. BACnet Specific Definitions:
   1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.

C. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

D. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

E. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

F. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

G. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

H. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO).

I. LAN: Local area network.

J. LNS: LonWorks Network Services.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

L. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

M. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

N. POT: Portable operator's terminal.

O. TCP/IP: Transport control protocol/Internet protocol..

P. UPS: Uninterruptible power supply.

Q. USB: Universal Serial Bus.

R. VAV: Variable air volume.

## 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

    a. Workstations.
    b. Gateways.
    c. Routers.
    d. DDC controllers.
    e. Enclosures.
    f. Electrical power devices.
    g. UPS units.
    h. Accessories.
    i. Instruments.
    j. Control dampers and actuators.
    k. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, gateway, and DDC controller.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details where applicable.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Plan Drawings indicating the following:

a. Screened backgrounds of walls, HVAC equipment, ductwork and piping.
b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
c. Each desktop workstation, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
e. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

4. Schematic drawings for each controlled HVAC system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
c. A graphic showing location of control I/O in proper relationship to HVAC system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

D. BMS System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, controller types and applications, gateways, routers and other network devices, and power supplies.

2. The BMS shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
3. Any and all components of the BMS that are connected via field bus or IP network, including the network controllers, field controllers, application specific controllers, and user interface software, system and controller programming tools and software applications shall be designed, engineered, and tested to work together as a complete building management system, and shall be manufactured by the same BMS manufacturer. Systems that use or require network controllers, field controllers, application specific controllers, and user interface software, programming tools and software from more than one BMS manufacturer shall not be accepted.
4. All points of user interface shall be on standard computing devices that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these devices will be a standard Web Browser.
5. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification.
6. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.
7. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
8. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as not to impede or delay the work of associated trade
9. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

   a. Operator information, alarm management and control functions.

   b. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

   c. Diagnostic monitoring and reporting of BMS functions.

   d. Energy management.

   e. Standard applications for terminal HVAC systems.

f. Enterprise-wide information and control access.

g. Offsite monitoring and management access.

h. Indoor Air Quality monitoring and control, if applicable to project.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings, reflected ceiling plan(s), and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Welding certificates.

C. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

D. Product Test Reports: For each product that requires testing to be performed by manufacturer.

E. Preconstruction Test Reports: For each separate test performed.

F. Source quality-control reports.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

## 1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with

## 1.7 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within 150 miles of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

D. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: one year from date of Substantial Completion.

1.9 ELECTRICAL SERVICE

A. The HVAC Controls Contractor shall be responsible for the provision of line voltage electrical power to each individual HVAC control component that requires it. As each HVAC Control system has unique electrical requirements, it is unreasonable for the project documents to account for each scenario by designing for worst case. Rather, it is logical for the respective HVAC Controls Contractor to account for the specific power requirements of their individual system. As such, the HVAC Controls Contractor shall either self-perform this work using licensed electricians of their employ or contract with the project's electrical contractor to perform this work. In doing so, all electrical specifications from the project manual apply. All work shall be performed and completed to comply with and maintain all electrical warranties.

1.10 SCHEDULE OF VALUES

A. By the very nature of HVAC Control systems, much of the true value to the Owner occurs with the final programming to make the system operational and commissioning to ensure compliance with the design sequences and provide operation efficiency. Unfortunately, to often, the DDC Contractor focuses on the equipment and infrastructure installation and does not prioritize the latter phases of a successful DDC system implementation. To help mitigate this, the following allocation of fee for the work shall apply:

- Approved submittals 5%
- Delivery of equipment to site 25%
- Installation of equipment to/Hardware 40%
- Software and System programming 15%
- System commissioning, verification, close-out 15%

These allocations reference the DDC price only. Any applicable withholding of retainage are separate and above.

B. Pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. 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.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

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

H. 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.

## 1.11 GAS DETECTION EQUIPMENT

A. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F; with 2 factory-calibrated alarm levels at 50 and 100 ppm.

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.

C. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

## 1.12 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Casing: Galvanized-steel frame.
2. Flow Straightener: Aluminum honeycomb, 3/4-inch parallel cell, 3 inches deep.
3. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

1.13 THERMOSTATS

A. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF".
2. Mount on single electric switch box.

B. 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."

C. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, and the following:

1. Reset: Manual.

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

E. 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.

F. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

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

G. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above set point.

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

## 1.14 HUMIDISTATS

A. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

## 1.15 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 15 Section "Common Motor 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. Nonspring-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. Nonspring-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. Manufacturers:

   a. Belimo Aircontrols (USA), Inc.

   b. Johnson Controls, Inc.

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 with 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 nonspring-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: 40 to 104 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 30 seconds;

## 1.16 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 globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:

a. Two Position: Line size.
b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-

way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

C. Butterfly Valves: 200-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Lug.
2. Disc Type: Stainless steel.
3. Sizing: 1-psig maximum pressure drop at design flow rate.

D. Pressure Independent Characterized control Valves: Brass body, brass trim, two ports, replaceable plugs and seats, and union and threaded ends.

1. Rating: 600 psi at 212 of operating conditions.
2. Sizing: 5-50 psi operating range to close against 200 psi.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics.

## 1.17 DAMPERS

A. Dampers: AMCA-rated, parallel or opposed-blade 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 with maximum blade width of 8 inches and length of 48 inches.

1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze 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 minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. 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.

# PART 2 - PRODUCTS

## 2.1 DDC SYSTEM MANUFACTURERS

1. Johnson Controls, Inc.
2. Trane

## 2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and

processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.3 WEB ACCESS

A. DDC system shall be web based or web compatible.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on supervisory controller, designed around open standards of web technology. DDC system shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet[ through Owner's LAN].
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. web access shall be password protected.

2. Web-Compatible Access to DDC System:

a. workstation shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system shall support web browser access to building data. Operator using a standard web browser shall be able to access control graphics and change adjustable set points.
c. Web access shall be password protected.

## 2.4 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
b. Binary point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
c. Alarms of analog and digital points connected to DDC system shall be displayed within 30 seconds of activation or change of state.
d. Graphic display refresh shall update within eight seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

C. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

D. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage:

a. Provide workstation and supervisory controllers with data storage indicated.

3. Cloud Storage:

a. Provide [application-based] [and] [web browser] interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

E. DDC Data Access:

1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

F. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

G. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

H. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

   a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated[, cooled] and ventilated as required by instrument and application.

I. Electric Power Quality:

1. Power-Line Surges:

   a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
   b. Do not use fuses for surge protection.
   c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

J. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

## 2.5 SYSTEM ARCHITECTURE

A. System architecture shall perform modifications without having to remove and replace existing network equipment.

B. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

C. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

## 2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop workstation with hardwired connection through LAN port.
2. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room or outdoor chiller yard.
4. Each cooling tower location.
5. Each different roof level with roof-mounted air-handling units or rooftop units.

D. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. POT:

1. Connect DDC controller through a communications port local to controller.

F. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

G. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

## 2.7 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers

## 2.8 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

## 2.9 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.

2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: 2.2 GHZ.
2. RAM:

   a. Capacity: 8 GB.

3. Hard Drive:

   a. Media: Rotating disc, nominal rotational speed of 7200 rpm.
   b. Number of Hard Drives: One.
   c. Capacity: ITB.

4. At least four expansion slots of 64 bit.
5. Video Card:

   a. Resolution: 1920 by 1200 pixels.
   b. RAM: GB 16B.

6. Network Interface Card: Include card with connection, as applicable.

   a. 10-100-1000 base TX Ethernet with RJ45 connector port.
   b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 a/b/g/n.

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
2. I/O Ports:

   a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
   b. One serial port.
   c. One parallel port.
   d. Two PS/2 ports.
   e. One RJ-45.
   f. One stereo line-in and headphone/line-out on back panel.
   g. One microphone and headphone connector on front panel.
   h. One IEEE 1394 on front and back panel with PCI-e card.
   i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

a. Color display with 21” diagonal viewable area.
b. Antiglare display.
c. Tilt adjustable base.
d. Energy Star compliant.
e. Resolution: 1920 by 1080 pixels at 60 Hz.
f. Number of Displays: One.

H. I/O Cabling: Include applicable cabling to connect I/O devices.

## 2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple-network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.

4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

   a. Operator access to DDC system shall be under password control.
   b. An alphanumeric password shall be field assignable to each operator.
   c. Operators shall be able to access DDC system by entry of proper password.
   d. Operator password shall be same regardless of which computer or other interface means is used.
   e. Additions or changes made to passwords shall be updated automatically.
   f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
   g. Software shall have at least five access levels.
   h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
   i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Operators shall be able to perform commands including, but not limited to, the following:

   a. Start or stop selected equipment.
   b. Adjust set points.
   c. Add, modify, and delete time programming.
   d. Enable and disable process execution.
   e. Lock and unlock alarm reporting for each point.
   f. Enable and disable totalization for each point.
   g. Enable and disable trending for each point.
   h. Override control loop set points.
   i. Enter temporary override schedules.
   j. Define holiday schedules.
   k. Change time and date.
   l. Enter and modify analog alarm limits.
   m. Enter and modify analog warning limits.
   n. View limits.
   o. Enable and disable demand limiting.
   p. Enable and disable duty cycle.
   q. Display logic programming for each control sequence.

8. Reporting:

   a. Generated automatically and manually.
   b. Sent to displays, printers and disk files.
   c. Types of Reporting:

      1) General listing of points.
      2) List points currently in alarm.

3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

9. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Mobile, Web Based User Interfacce (MUI):

i. The mobile, web based, user interface shall be HTML5-compliant and provide device-agnostic access to the system from smartphones, tablets, portable and desktop computers. User Interfaces that require software installation on the client device (e.g. Java, MicrosoftSilverlight®, Adobe® Flash®), or software down-loads from an online app store shall not be acceptable for these purposes.

ii. The mobile user interface shall provide system operators with a simple location-based navigation approach to finding information, including the ability to search for any location by name and to bookmark a location in a standard browser.

iii. The mobile user interface shall organize and display information using customer specific locations and spaces. At a minimum, the user interface shall provide:

- Organization of all space, equipment and point information in a familiar way (using standard equipment names and location descriptions), reducing the need for extensive training prior to use.
- A navigation mechanism or tree for users to select the specific location or space for accessing information – only spaces and locations in the navigation tree or equipment serving that space, nothing more.
- The ability to search for and/or bookmark any location, space, or equipment by name for quick access to critical or troublesome areas.
- Application of the same navigation mechanisms across any client device (e.g. Smart phone, tablet, personal computer) for consistency and ease of use.

iv. The same user interface elements shall be accessible from any type of personal computer or mobile device running any type of operating system supported (e.g. iOS, Android, Windows®). It shall automatically adapt and optimize the display for the screen size and touch screen navigation.

v. The user interface shall provide support for up to 50 concurrent users from individuals with defined access to the system.

D. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable
4. Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.
5. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
6. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
7. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
8. Graphics are to be online programmable and under password control.
9. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
10. Graphics shall also contain software points.
11. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
12. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
13. Display operator accessed data on the monitor.
14. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
15. Include operator with means to directly access graphics without going through penetration path.
16. Dynamic data shall be assignable to graphics.
17. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
18. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
19. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
20. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.

c. Keyboard equivalent shall be available for those operators with that preference.

21. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
22. Help Features:

a. On-line context-sensitive help utility to facilitate operator training and understanding.
b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

c. Available for Every Menu Item:

1) Index items for each system menu item.

23. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[ similar to those indicated].
b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

1) Define background screens.
2) Define connecting lines and curves.
3) Locate, orient and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

E. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

a. Room layouts with room identification and name.
b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
c. Location and identification of each hardware point being controlled or monitored by DDC system.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers[, gateways] [and other network devices].
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

   a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
   b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
   c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
   d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.

6. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
7. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [workstation] for historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on [workstation] hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

    a. Alarm history.
    b. System messages.
    c. System events.
    d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

K. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

L. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be any of the following:

a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.

c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

## 2.11 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

B. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.

## 2.12 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

F. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers [that perform scheduling ]shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

G. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

## 2.13 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers [that perform scheduling ]shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a

2.14 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

2.15 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. Control functions shall be executed within controllers using DDC algorithms.
3. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.

b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

C. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

D. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

E. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

F. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

G. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

H. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

I. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

## 2.16 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.

## 2.17 RELAYS

A. General-Purpose Relays:

B. Current Sensing Relay:
   1. Monitors ac current.
   2. Independent adjustable controls for pickup and dropout current.
   3. Energized when supply voltage is present and current is above pickup setting.
   4. De-energizes when monitored current is below dropout current.
   5. Dropout current is adjustable from 50 to 95 percent of pickup current.
   6. Include a current transformer, if required for application.
   7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

C. Combination On-Off Status Sensor and On-Off Relay:
   1. Description:
      a. On-off control and status indication in a single device.
      b. LED status indication of activated relay and current trigger.
      c. Closed-Open-Auto override switch located on the load side of the relay.
   2. Status Indication:
      a. Current Sensor Range: As required by application.
   3. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
   4. Enclosure: NEMA 250, Type 1 enclosure.

## 2.18 ELECTRICAL POWER DEVICES

A. Transformers:

   1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.

B. DC Power Supply:
   1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.

## 2.19 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch (50- to 65-mm) lay.
2. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
3. Conductor colors shall be black (hot), white (neutral), and green (ground).
4. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:
1. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch (50- to 65-mm) lay.
2. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
3. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
4. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
5. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
6. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
1. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch (50- to 65-mm) lay.
2. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
3. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
4. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
5. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
6. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Cable shall be plenum rated.
3. Cable shall comply with NFPA 70.
4. Cable shall have a unique color that is different from other cables used on Project.

## 2.20 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.21 ACCESSORIES

A. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Manual Valves:

1. Needle Type:
   a. PTFE packing.
   b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
   c. Aluminum T-bar handle.
   d. Include tubing connections.

2. Ball Type:
   a. Body: Bronze ASTM B62 or ASTM B61.
   b. Ball: Type 316 stainless steel.
   c. Stem: Type 316 stainless steel.
   d. Seats: Reinforced PTFE.
   e. Packing Ring: Reinforced PTFE.
   f. Lever: Stainless steel with a vinyl grip.
   g. 600 WOG.
   h. Threaded end connections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:
   a. Fire-alarm system

## 3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a <Insert value> force.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 07 84 13 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 92 00 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.

4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

a. Laboratory exhaust-air streams.
b. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

## 3.4 OPERATOR WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.

B. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.

4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

## 3.5 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

B. Test gateway to verify that communication interface functions properly.

## 3.6 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

B. Test router to verify that communication interface functions properly.

## 3.7 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

## 3.8 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. Relays.
6. Accessories.
7. Instruments.
8. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use corrosion-resistant-coated steel strut and hardware.
2. For NEMA 250, Type 4 Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

## 3.9 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 26 28 16 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

## 3.10 NETWORK INSTALLATION

A. Install balanced twisted pair cable when connecting between the following network devices[ located in same building]:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair cable when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

C. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

## 3.11 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

## 3.12 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 26 05 23 "Control-Voltage Electrical Power Cables."
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

   a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

3. Provide strain relief.
4. Terminate wiring in a junction box.

   a. Clamp cable over jacket in junction box.

b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

5. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
6. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
7. Use shielded cable to transmitters.
8. Use shielded cable to temperature sensors.
9. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.

## 3.13 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

B. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Results: Record test results and submit copy of test results for Project record.

## 3.14 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

E. Control Valve Checkout:

1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment is secure.
4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

F. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

   a. Verify sensing element type and proper material.
   b. Verify length and insertion.

3.15 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

## 3.16 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

## 3.17 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

## 3.18 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.

8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.

      1) Identify I/O points for future reference.
      2) Simulate abnormal conditions to demonstrate proper function of safety devices.
      3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.

4. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.

5. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify

3.19 FINAL REVIEW

A. Submit written request to Architect Engineer when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Engineer shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Correct sequence of

operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

c. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
d. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
e. Trends, summaries, logs and reports set-up for Project.
f. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
g. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
h. Data entry to show Project-specific customizing capability including parameter changes.
i. Execution of digital and analog commands in graphic mode.

## 3.20 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

## 3.21 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

B. Commissioning Requirements

1. Fully commission all aspects of the BMS work.

i. Promptly rectify all listed deficiencies and submit a document summarizing completion to the Engineer.

C. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

a. Provide not less than five days of training total.
b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
c. Total days of training shall be broken into not more than two separate training classes.

D. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

    a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.

b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

END OF SECTION 23 09 23