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USACE / NAVFAC / AFCESA **UFGS-15951 (*-TBD-* 2003)**

Preparing Activity: USACE **Superseding UFGS-15951A (December 2001)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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DIVISION 15 - MECHANICAL

SECTION 15951

DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS

***-TBD-*/03**

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 15951

DIRECT DIGITAL CONTROL FOR HVAC AND OTHER LOCAL BUILDING SYSTEMS
-TBD-/03

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NOTE: This guide specification covers the requirements for direct digital control for HVAC and other local building systems..

Comments and suggestions on this guide specification are welcome and may be submitted through the Techinfo website at:
http://www.hnd.usace.army.mil/techinfo/

This guide specification uses the English/metric tags only for the determination of which type of units to display on indicating devices.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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NOTE: If it is necessary to remove a subpart from this document, retain the subpart number (SPT tags), replace the title (in TTL tags) with the word "Omitted", and remove the text of the subpart.
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PART 1 GENERAL

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NOTE: This specification covers installation of local (building-level) controls using LonWorks-based DDC. It is primarily intended for building level control systems which are to be integrated into a Utility Monitoring and Control System (UMCS) as specified in Section 13801 UTILITY MONITORING AND CONTROL SYSTEM (UMCS). For projects that require the building system to operate in a stand-alone mode, the designer must include the necessary requirements from Section 13801. Some requirements

to include in this case are:
1) LonWorks Network Configuration Tool
2) Monitoring and Control Software
3) Computer Workstations and Servers
Further details on specifying a stand-alone building system are in UFC 3-410-02.

The HVAC Control System design shall be in accordance with UFC 3-410-02. This specification is based on the use of standard HVAC control systems and the designer shall coordinate the design with this specification. Additionally, the standard drawings, as delineated in UFC 3-410-02, must be used in the preparation of the contract drawings and those drawings must be included in the completed design package. Templates for typical contract type drawings, based on the standard drawings in UFC 3-410-02, have been developed and are available in AutoCAD and MicroStation formats on the Internet on the TECHINFO web site **located at:**
http://www.hnd.usace.army.mil/techinfo/index.asp
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1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change to the guide specification.

The listed references should not be manually edited except to add new references. References not used in the text will be deleted from this paragraph during the SpecsIntact reference reconciliation process.
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 500	(1989; Rev994) Test Methods for Louvers, Dampers and Shutters

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/ASHRAE 15	(2001) Safety Code for Mechanical Refrigeration
ANSI C12.1	(1995) Code for Electricity Metering
ANSI/EIA-709.1B	(2002) Control Network Protocol Specification

ANSI/EIA-709.3	(1998) Free-Topology Twisted-Pair Channel Specification
ANSI/FCI 70-2	(2003) Control Valve Seat Leakage

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE Hdbk	(2001) Fundamentals Handbook

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 269	(1996) Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM B 88	(1996) Seamless Copper Water Tube
ASTM B 88M	(1996) Seamless Copper Water Tube (Metric)
ASTM D 1693	(1997a) Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	(1997) Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

ASME INTERNATIONAL (ASME)

ASME B16.34	(1996) Valves - Flanged, Threaded, and Welding End
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPVC SEC VIII D1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage

FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC EMC	FCC Electromagnetic Compliance Requirements
FCC Part 15	FCC Rules and Regulations Part 15: Radio Frequency Devices (Volume II)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 142	(1991) IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

INSTRUMENT SOCIETY OF AMERICA (ISA)

ISA S7.0.01	(1996) Quality Standard for Instrument Air

THE LONMARK INTEROPERABILITY ASSOCIATION (LIA)

LonMark Interoperability Guide	(2002) LonMark Application-Layer Interoperability Guidelines; Version 3.3
LonMark SNVT Master List	(2002) LonMark SNVT Master List; Version 11, Revision 2
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.0B

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1997) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems

UNDERWRITERS LABORATORIES (UL)

UL 268A	(1998) Smoke Detectors for Duct Application
UL 1585	(2001) Class 2 and Class 3 Transformers
UL 555	(1995) Standard for Fire Dampers
UL 555S	(1996; R2000) Leakage Rated Dampers for Use in Smoke Control Systems
UL 94	(1996; Rev thru Jul 1998) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 916	(2002) Energy Management Equipment

1.2 SYSTEM DESCRIPTION

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NOTE: Designer is to add location and site specific requirements.

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The Direct Digital Control (DDC) system shall be a complete system suitable for the control of the heating, ventilating and air conditioning (HVAC) and other building-level systems as specified and shown.

1.2.1 System Requirements

Systems installed under this guide specification shall have the following characteristics:.

a. The control system shall be an open implementation of LonWorks technology using ANSI/EIA-709.1B as the communications protocol and using LonMark Standard Network Variable Types (SNVTs) as defined in LonMark SNVT Master List for communication over the network.

b. LonWorks Network Services (LNS) shall be used for all network management including addressing and binding. A copy of the LNS database shall be submitted to the project site as specified.

c. The hardware shall perform the control sequences as specified and shown to provide control of the equipment as specified and shown.

d. Control sequence logic shall reside in DDC hardware in the building. The building control network shall not be dependent upon connection to a Utility Monitoring and Control System (UMCS) for performance of control sequences in this specification. The hardware shall, to the greatest extent practical, perform the sequences without reliance on the building network.

e. The hardware shall be installed such that individual control equipment can be replaced by similar control equipment from other equipment manufacturers with no loss of system functionality.

f. All necessary documentation, configuration information, configuration tools, programs, drivers, and other software shall be licensed to and otherwise remain with the government such that the government or their agents are able to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.

g. The contractor shall provide sufficient documentation and data, including rights to documentation and data, such that the government or their agents can execute work to perform repair, replacement, upgrades, and expansions of the system without subsequent or future dependence on the contractor.

h. Hardware shall be installed and configured such that the government or their agents are able to perform repair, replacement, and upgrades of individual hardware without further interaction with the contractor.

i. Control hardware shall be installed and configured to provide all input and output Standard Network Variables (SNVTs) as shown.

j. All DDC devices installed under this specification shall communicate via ANSI/EIA-709.1B. The control system shall be installed such that a SNVT output from any node on the network can be bound to any other node in the domain.

1.2.2 Verification of Dimensions

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting

Officer of any discrepancy before performing any work.

1.2.3 Drawings

The government will not indicate all offsets, fittings, and accessories that may be required on the drawings. The Contractor shall carefully investigate the mechanical, electrical, and finish conditions that could affect the work to be performed, shall arrange such work accordingly, and shall furnish all work necessary to meet such conditions.

1.3 SUBMITTALS

****

NOTE: The submittals included in this guide specification are critical to the implementation of the project. Additional submittals should be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if an additional submittal for the item should be required.

Place a "G" within submittal tags following a submittal item if Government approval for that item is required. Government approval should be required only for items deemed sufficiently critical, complex, or aesthetically significant to merit such action. Note that all submittals included in this guide specification are critical and require government review.

For submittals requiring Government approval, a code of up to three characters within submittal tags may be used following the "G" designation to indicate the approving authority.

Submittal items not designated with a "G" are considered as being for information only.

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NOTE: The acquisition of all technical data, data bases and computer software items that are identified herein will be accomplished strictly in accordance with the Federal Acquisition Regulation (FAR) and the Department of Defense Acquisition Regulation Supplement (DOD FARS). Those regulations as well as the Army and Corps of Engineers implementations thereof should also be consulted to ensure that a delivery of critical items of technical data is not inadvertently lost. Specifically, the Rights in Technical Data and Computer Software Clause, DOD FARS 52.227-7013, and the Data Requirements Clause, DOD FAR 52.227-7031, as well as any requisite software licensing agreements will be made a part of the CONTRACT CLAUSES or SPECIAL CONTRACT REQUIREMENTS. In

addition, the appropriate DD Form 1423 Contract Data Requirements List, will be filled out for each distinct deliverable data item and made a part of the contract. Where necessary, a DD Form 1664, Data Item Description, will be used to explain and more fully identify the data items listed on the DD Form 1423. It is to be noted that all of these clauses and forms are required to ensure the delivery of the data in question and that such data is obtained with the requisite rights to use by the Government.

Include with the request for proposals a completed DD Form 1423, Contract Data Requirements List. This form is essential to obtain delivery of all documentation. Each deliverable will be clearly specified, both description and quantity being required.
****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.

Technical data packages consisting of technical data and computer software (meaning technical data which relates to computer software) which are specifically identified in this project and which may be defined/required in other specifications shall be delivered strictly in accordance with the CONTRACT CLAUSES and in accordance with the Contract Data Requirements List, DD Form 1423. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. All submittals not specified as technical data packages are considered 'shop drawings' under FAR and shall contain no proprietary information and be delivered with unrestricted rights.

The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES, the CONTRACT CLAUSES and DD Form 1423 and according to the timing specified in paragraph PROJECT TIMING:

SD-02 Shop Drawings

DDC Contractor Design Drawings; G, [___]

z Draft As-built Drawings; G, [___]

Final As-built Drawings; G, [___]

SD-03 Product Data

Manufacturer's Catalog Data; G, [___]

Product specific catalog cuts shall be in booklet form, indexed to unique identifiers, and shall consist of data sheets that document compliance with the specification. Where multiple components are shown on a catalog cut, the application specific component shall be marked. Markings which are not reproduced when photo-copied shall not be used.

Programming Software; G, [___]

Programming software for each General Purpose Programmable Controller (GPPC) shall be submitted as a Technical Data Package and shall be licensd to the project site. Software shall be submitted on CD-ROM and [__] hard copies of the software user manual shall be submitted for each piece of software provided.

GPPC Application Programs; G, [___]

The installed GPPC Application Programs shall be submitted on CD-ROM as a Technical Data Package. The CD-ROM shall include a list or table of contents clearly indicating which application program is associated with each device. [2][___] copies of the GPPC Application Programs CD-ROM shall be submitted.

XIF files; G, [___]

External interface files (XIF files) shall be submitted as a technical data package for each model of DDC Hardware furnished under this specification. XIF files shall be submitted on CD-ROM.

LNS Database

Two copies of the LNS Database for the complete control network shall be submitted as a Technical Data Package. Each copy shall be on CD-ROM and shall be clearly marked identifying it as the LNS Database for the work covered under this specification and with the date of the most recent database modification.

LNS Plug-in

LNS Plug-ins for each Application Specific Controller shall be submitted as a Technical Data Package. LNS Plug-ins distributed under a license shall be licensed to the project site. Plug-ins shall be submitted on CD-ROM and hard copy manuals, if available, shall be submitted for each plug-in provided.

SD-05 Design Data

Network Bandwidth Usage Calculations; G, [___]

Network Bandwidth Usage Calculations may be submitted as a Technical Data Package.

SD-06 Test Reports

Start-Up and Testing Report; G, [___]

The Start-Up and Testing Report may be submitted as a Technical Data Package.

PVT Procedures; G, [___]

PVT Procedures may be submitted as a Technical Data Package.

PVT Report; G, [___]

The PVT Report may be submitted as a Technical Data Package.

SD-07 Certificates

Air Storage Tank; G, [___]

SD-10 Operation and Maintenance Data

Operation and Maintenance Manual; G, [___]

[2][___] copies of the Operation and Maintenance Manual, indexed and in booklet form and shall be submitted. The Operation and Maintenance Manual shall be a single volume or in separate volumes, and may be submitted as a technical data package.

Training Documentation; G, [___]

1.4 DELIVERY AND STORAGE

Products shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants, within the storage condition limits published by the equipment manufacturer.

1.5 OPERATION AND MAINTENANCE MANUAL (O&M Manual)

The HVAC control System Operation and Maintenance Manual shall include:

a. "Manufacturer Data Package 3" as specified in Section 01781 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. "Manufacturer Data Package 4" as described in Section 01781 for all air compressors.

c. HVAC control system sequences of operation.

d. Procedures for the HVAC system start-up, operation and shut-down.

e. As-built HVAC control system detail drawings.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference.

h. Qualified service organization list.

i. Start-Up and Testing Report.

j. Performance Verification Test (PVT) Procedures and Report.

1.6 MAINTENANCE AND SERVICE

****
NOTE: The maintenance and service to be provided by the Contractor for the duration of the maintenance contract is specified in this paragraph. The Maintenance and Service may need to be a separate bid item funded by O&M funds.

Requirements should be coordinated with "WARRANTY MANAGEMENT" in Section 01780A CLOSEOUT SUBMITTALS
****

Services, materials and equipment shall be provided as necessary to maintain the entire system in an operational state as specified for a period of one year after successful completion and acceptance of the Performance Verification Test. Impacts on facility operations shall be minimized.

1.6.1 Description of Work

The adjustment and repair of the system shall include the manufacturer's required sensor and actuator (including transducer) calibration, span and range adjustment.

1.6.2 Personnel

Service personnel shall be qualified to accomplish work promptly and satisfactorily. The Government shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

1.6.3 Scheduled Inspections

Two inspections shall be performed at six-month intervals and all work required shall be performed. Inspections shall be scheduled in [June and December][___]. These inspections shall include:

a. Visual checks and operational tests of equipment.

b. Fan checks and filter changes for control system equipment.

c. Clean control system equipment including interior and exterior surfaces.

d. Check and calibrate each field device. Check and calibrate 50 percent of the total analog points during the first inspection. Check and calibrate the remaining 50 percent of the analog points during the second major inspection. Certify analog test instrumentation accuracy to be twice that of the device being calibrated. Randomly check at least 25 percent of all digital points for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital points during the second inspection.

e. Run system software diagnostics and correct diagnosed problems.

f. Resolve any previous outstanding problems.

1.6.4 Scheduled Work

This work shall be performed during regular working hours, Monday through Friday, excluding Federal holidays.

1.6.5 Emergency Service

The Government will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the system. A telephone number where the service supervisor can be reached at all times shall be provided. Service personnel shall be at the site within 24 hours after receiving a request for service. The control system shall be restored to proper operating condition as required per Section 01780A CLOSEOUT SUBMITTALS.

1.6.6 Operation

Scheduled adjustments and repairs shall include verification of the control system operation as demonstrated by the applicable tests of the performance verification test.

1.6.7 Records and Logs

Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

1.6.8 Work Requests

Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

1.6.9 System Modifications

Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Government. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

1.7 SURGE PROTECTION

1.7.1 Power-Line Surge Protection

Equipment connected to ac circuits shall be protected against or withstand power-line surges. Equipment protection shall meet the requirements of IEEE C62.41. Fuses shall not be used for surge protection.

1.7.2 Surge Protection for Transmitter and Control Wiring

****
NOTE: Determine if any additional inputs or outputs require surge protection and show the requirement for them on the drawings.
****

DDC hardware shall be protected against or withstand surges induced on control and transmitter wiring installed outdoors and as shown. The equipment protection shall be tested in the normal mode and in the common mode, using the following two waveforms:

a. A 10-microsecond by 1,000-microsecond waveform with a peak voltage of 1,500 volts and a peak current of 60 amperes.

b. An eight microsecond by 20-microsecond waveform with a peak voltage of 1,000 volts and a peak current of 500 amperes.

1.8 BUILDING CONTROL NETWORK

****
NOTE: TP/FT-10 is specified as the media type for the local control network as it is an ANSI Standard and the most common media type for a LonWorks network. IP can be used as a high-speed backbone when needed, and guidance on including IP is found in the designer notes of this document and in UFC 3-410-02

TP/FT-10 (and IP if needed) will generally meet all the needs of the building control network, and the use of other media types is strongly discouraged (see guidance in UFC 3-410-02).
****

The building control network shall consist of a backbone and one or more local control busses as specified.

1.8.1 Backbone Media

The backbone shall be a TP/FT-10 network in accordance with ANSI/EIA-709.3 or an IP network as specified in Section 13801 UTILITY MONITORING AND CONTROL SYSTEMS according to the following criteria:

a. The backbone shall be an IP network as specified in Section 13801 if both of the following conditions are met:

(1) the Network Bandwidth Calculations for a heavily loaded network show that more than 70% of the 78kbps (kilobits per second) bandwidth is used or the Network Bandwidth Calculations for a normally loaded network show that more than 30% of the 78kbps bandwidth is used.

(2) the government has approved the Network Bandwidth Calculations submittal.

b. The backbone shall be a TP/FT-10 network otherwise.

1.8.2 Control Network Requirements

The control network shall meet the following requirements:

a. The backbone shall have no control devices connected to it. Only ANSI-709.1 routers and ANSI-709.3 to IP routers (as specified in Section 13801 UTILITY MONITORING AND CONTROL SYSTEMS) may be connected to the backbone.

****
NOTE: Designer must indicate Building Point of Connection (BPOC) location
****

b. The backbone shall be installed such that a router at the the Building Point of Connection (BPOC) location [as shown][___] may be connected to the backbone.

c. The local control bus shall use ANSI/EIA-709.1B over a TP/FT-10 network in doubly-terminated bus topology in accordance with ANSI/EIA-709.3

d. The local control busses shall be installed such that no node (device connected to the control network) has more than two ANSI-709.1 routers and ANSI-709.3 repeaters (in any combination) between it and the backbone, including the router connected to the backbone.

e. All DDC Hardware shall connect to a local control bus.

f. All DDD Hardware shall be locally powered; link power is not acceptable.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

Units of the same type of equipment shall be products of a single manufacturer. Each major component of equipment shall have the manufacturer's name and address, and the model and serial number in a conspicuous place. Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of these and similar products. The standard products shall have been in a satisfactory commercial or industrial use for two years prior to use on this project. The two year use shall include applications of equipment and materials under similar circumstances and of similar size. DDC Hardware not meeting the two-year field service requirement shall be acceptable provided it has been successfully used by the contractor in a minimum of two previous projects. The equipment items shall be supported by a service organization. Items of the same type and purpose shall be identical, including equipment, assemblies, parts and components. Manufacturer's catalog data sheets documenting compliance with product specifications shall be submitted as specified for each product installed under this specification.

2.1.1 Operation Environment Requirements

All products shall be rated for continuous operation under the following conditions:

a. Pressure: Pressure conditions normally encountered in the installed location.

b. Vibration: Vibration conditions normally encountered in the installed location.

c. Temperature:
(1) Products installed indoors: Ambient temperatures in the range of 0 to 50 degreesC (32 to 112 degreesF) and temperature conditions outside this range normally encountered at the installed location.

****
NOTE: Designer must decide if suggested outside air temperature range is sufficient, and provide a range if it's not.
****

(2) Products installed outdoors or in unconditioned indoor spaces: Ambient temperatures in the range of [-37 to +66 degreesC (-35 to +151 degreesF)][___] and temperature conditions outside this range normally encountered at the installed location.

d. Humidity: 10% to 95% relative humidity, noncondensing and humidity conditions outside this range normally encountered at the installed location.

2.2 ENCLOSURES AND WEATHERSHIELDS

2.2.1 Enclosures

****
NOTE: For retrofit projects in older mechanical rooms consider specifying a Type 4 enclosure in Mechanical Rooms. Type 4 provides a greater degree of protection in dirty and wet environments than does Type 2. In outdoor or mechanical room applications where hosedown of the enclosure is anticipated, specify Type 4.
****

Enclosures shall meet the following minimum requirements:

a. Outdoors: Enclosures located outdoors shall meet NEMA 250 [Type 3][Type 4] requirements.

b. Mechanical and Electrical Rooms: Enclosures located in mechanical or electrical rooms shall meet NEMA 250 [Type 2][Type 4] requirements.

c. Other Locations: Enclosures in other locations including but not limited to occupied spaces, above ceilings, and plenum returns shall meet NEMA 250 Type 1 requirements.

Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

2.2.2 Weathershields

****
NOTE: Show locations of the weathershields for sensors located outdoors on the drawings.
****

Weathershields for sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient temperature of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the temperature sensor. Weathershields installed near outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the temperature sensor. Weathershields shall be constucted of galvanized steel painted white, aluminum or PVC.

2.3 TUBING

2.3.1 Copper

Copper tubing shall conform to ASTM B 88 and ASTM B 88M

2.3.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A 269

2.3.3 Plastic

Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification or better, and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.4 NETWORK HARDWARE

2.4.1 ANSI-709 Network Hardware

2.4.1.1 ANSI-709.1 Routers

ANSI-709.1 Routers (including routers configured as repeaters) shall meet the requirements of ANSI/EIA-709.1B and shall provide connection between two or more ANSI/EIA-709.3 TP/FT-10 channels.

2.4.1.2 ANSI-709.3 Repeaters

ANSI-709.3 Repeaters shall be physical layer repeaters in accordance with ANSI/EIA-709.3.

2.4.1.3 Gateways

Gateways shall perform bi-directional protocol translation to one non-ANSI/EIA-709.1 protocol to ANSI/EIA-709.1B. Gateways shall incorporate exactly two network connections: one shall be for connection to a TP/FT-10 network in accordance with ANSI/EIA-709.3 and the second shall be as required to communicate with the non-ANSI/EIA-709.1 network.

2.5 WIRING

2.5.1 Terminal Blocks

Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

2.5.2 Control Wiring for Binary Signals

Control wiring for binary signals shall be 18 AWG copper and shall be rated for 300-volt service.

2.5.3 Wiring for 120-Volt Circuits

Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.

2.5.4 Control Wiring for Analog Signals

Control Wiring for Analog Signals shall be 18 AWG, copper, single- or multiple-twisted, minimum 50mm (2inch)lay of twist, 100% shielded pairs, and shall have a 300-volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned-copper cable drain wire, and overall cable insulation.

2.5.5 Transformers

Transformers shall be UL 1585 approved. Transformers shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

2.6 AUTOMATIC CONTROL VALVES

****

NOTE: Ball valves are generally less expensive than globe valves, but because of potential cavitation problems should only be used in 2-position and chilled water applications. It is recommended that you coordinate their use with the local maintenance staff because unlike globe valves maintenance is more likely to require complete removal of the valve.

Show each valve's Kv (m^3/hr) and/or Cv (gal/min) on the Valve Schedule. Kv = 0.857 x Cv.

****

Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall meet ASME B16.34 pressure and temperature class ratings based on the design operating temperature and 150% of the system design operating pressure. Unless otherwise specified or shown, valve leakage shall meet ANSI/FCI 70-2 Class IV leakage rating (0.01% of valve Kv). Unless otherwise specified or shown, valves shall have globe-style bodies. Unless otherwise specified:

a. bodies for valves 40mm (1.5inches) and smaller shall be brass or bronze, with threaded or union ends

b. bodies for 50 mm (2inch) valves shall have threaded ends

c. bodies for valves 50 to 80mm (2 to 3inches) shall be of brass, bronze or iron.

d. bodies for valves 65mm (2.5inches) and larger shall be provided with flanged-end connections.

e. for modulating applications, valve Kv (Cv) shall be within 100 to 125% of the Kv (Cv) shown.

f. for two position applications (where the two positions are full open and full closed) the Kv (Cv) shall be the largest available for the valve size.

f. valve and actuator combination shall be normally open or normally closed as shown.

2.6.1 Ball Valves

Ball valves are permitted in two-position (open/closed) applications and in modulating chilled-water, condenser-water, and glycol service applications. In modulating applications a characterizing equal-percentage disk shall be used. Balls shall be stainless steel or nickel plated brass. Valves shall have blow-out proof stems. Valve to actuator linkage shall provide a thermal break in steam and high temperature hot water applications.

2.6.2 Butterfly Valves

Butterfly valves shall be threaded lug type suitable for dead-end service and modulation to the fully-closed position, with carbon-steel bodies and noncorrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -29 to +121 degreesC (-20 to +250 degreesF). The rated Kv (Cv) for butterfly valves shall be the value Kv (Cv) at 70% (60 degrees) open position. In two-way control applications, valve travel shall be limited to 70% (60 degrees) open position. Valve leakage shall meet ANSI/FCI 70-2 Class VI leakage rating.

2.6.3 Two-Way Valves

Two-way modulating valves, used in heating coil, cooling coil, humidifier, and high temperature hot water heat exchanger applications shall have an equal-percentage characteristic. Two-way modulating valves, used in steam coil and heat exchanger control applications shall have a linear characteristic.

2.6.4 Three-Way Valves

Three-way modulating valves shall provide equal percentage flow control with constant total flow throughout full plug travel.

2.6.5 Duct-Coil and Terminal-Unit-Coil Valves

Control valves with either flare-type or solder-type ends shall be provided for duct or terminal-unit coils. Flare nuts shall be furnished for each flare-type end valve.

2.6.6 Valves for Chilled-Water, Condenser-Water, and Glycol Service

Valve internal trim shall be Type 316 stainless steel. Valves 100mm (4inches) and larger shall be butterfly valves.

2.6.7 Valves for Hot-Water and Dual Temperature Service

Valves for hot water service above 99 degreesC (210 degreesF) and dual-temperature service shall have internal trim (including seats, seat rings, modulating plugs, and springs) of Type 316 stainless steel. Internal trim for valves controlling water below 99 degreesC (210 degreesF) shall be brass, bronze or Type 316 stainless steel. Nonmetallic valve parts shall be suitable for a minimum continuous operating temperature of 121 degreesC (250 degreesF) or 28 degreesC (50 degreesF) above the system design temperature, whichever is higher. Valves 100mm (4inches) and larger shall be butterfly valves.

2.6.8 Valves for Steam Service

Bodies for valves 100mm (4inches) and larger shall be iron or carbon steel. Internal valve trim shall be Type 316 stainless steel. If the specified Kv (Cv) is not available the valve manufacturer's next largest size shall be used.

2.6.9 Valves for High-Temperature Hot-Water Service

For high-temperature hot water service above 121 degreesC (250 degreesF) valve bodies shall be carbon steel, globe type with welded ends on valves 25mm (1inch) and larger. Valves smaller than 25mm (1inch) shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE). Internal valve trim shall be Type 316 stainless steel.

2.7 DAMPERS

2.7.1 Damper Assembly

A single damper section shall have blades no longer than 1.2m (48inch) and shall be no higher than 1.8m (72inch). Maximum damper blade width shall be 203mm (8in). Larger sizes shall be made from a combination of sections. Dampers shall be steel, or other materials where shown. Flat blades shall be made rigid by folding the edges. Blade-operating linkages shall be within the frame so that blade-connecting devices within the same damper section shall not be located directly in the air stream. Damper axles shall be 13mm (0.5inch) minimum, plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings. Pressure drop through dampers shall not exceed 10Pa (0.04inches water gauge) at 5.1m/s (1,000ft/min) in the wide-open position. Frames shall not be less than 50mm (2inch)in width. Dampers shall be tested in accordance with AMCA 500.

2.7.2 Operating Linkages

Operating links external to dampers, such as crankarms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least 300% of the maximum required damper-operating force. Rod lengths shall be adjustable. Links shall be brass, bronze, zinc-coated steel, or stainless steel. Working parts of joints and clevises shall be brass, bronze, or stainless steel. Adjustments of crankarms shall control the open and closed positions of dampers.

2.7.3 Damper Types

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NOTE: The designer should consider the application requirements and edit the leakage ratings as needed. Show exceptions to these specifications in the Damper Schedule.

AMCA 500 leakage classifications at 4 iwc (1017Pa) static:

Class 1: 8 cfm per square foot of (406L/s per square meter) damper area.

Class 2: 20 cfm/sf (102L/s per square meter).

Class 3: 40 cfm/sf (203L/s per square meter).

Class 4: 80 cfm/sf (406L/s per square meter).

Consider specifying very low leakage (Class 1) and/or thermally broken (barrier) frames for OA dampers in very cold climates and/or where unit runs 24/7 during unoccupied mode. Edit specification as necessary.

****

2.7.3.1 Outside Air, Return Air, and Relief Air Dampers

Outside air, return air and relief air dampers shall be provided where shown and shall be parallel-blade or opposed blade type as shown on the Damper Schedule. Blades shall have interlocking edges and shall be provided with compressible seals at points of contact. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Unless otherwise shown, dampers shall be AMCA 500 Class 2 and shall not leak in excess of 102L/s per square meter (20cfm per square foot) at 1017Pa (4 inches water gauge) static pressure when closed. Outside air damper seals shall be suitable for an operating temperature range of -40 to +75 degrees C (-40 to +167 degrees F). Dampers shall be rated at not less than 10m/s

(2000ft/min) air velocity.

2.7.3.2 Mechanical Rooms and Other Utility Space Ventilation Dampers

Utility space ventilation dampers shall be as shown. Unless otherwise shown, dampers shall be AMCA 500 class 4 and shall not leak in excess of 406L/s per square meter (80cfm per square foot) at 1017Pa (4 inches water gauge) static pressure when closed. Dampers shall be rated at not less than 7.6m/s (1500ft/min) air velocity.

2.7.3.3 Smoke Dampers

Smoke-damper and actuator assembly shall meet the current requirements of NFPA 90A, UL 555, and UL 555S. Combination fire and smoke dampers shall be rated for 121 degreesC (205 degreesF) Class II leakage per UL 555S.

2.8 SENSORS AND INSTRUMENTATION

Unless otherwise specified, sensors and instrumentation shall incorporate an integral transmitter or be provided with a transmitter co-located with the sensor. Sensors and instrumentation, including their transmitters, shall meet the specified accuracy and drift requirements at the input of the connected DDC Hardware's analog-to-digital conversion.

2.8.1 Transmitters

The transmitter shall match the characteristics of the sensor. Transmitters providing analog values shall produce a linear 4-20mADC, 0-10VDC or SNVT output corresponding to the required operating range and shall have zero and span adjustment. Transmitters providing binary values shall have dry contacts or SNVT output. Transmitters with SNVT output are ASCs and shall meet all ASC requirements.

2.8.2 Temperature Sensors

2.8.2.1 Sensor Ranges and Accuracy

Temperature sensors may be provided without transmitters.

a. Conditioned Space Temperature

    (1) Operating Range: +10 to +30 degreesC (+50 to +86 degreesF)

    (2) Accuracy: +/-0.5 degreeC (1 degreeF) over the operating range.

    (3) Drift: Maximum 0.5 degreeC (1 degreeF) per year

b. Unconditioned Space Temperature

    (1) Operating Range: -7 to +66 degreesC (+20 to +150 degreesF)

    (2) Accuracy: +/-0.5 degreeC (1 degreeF) over the range of -1 to +55 degreesC (+30 to +131 degreesF) and +/-2 degreesC (4 degreesF) over the rest or the operating range.

    (3) Drift: Maximum 0.5 degreeC (1 degreeF) per year

c. Duct Temperature

(1) Operating Range: +5 to +60 degrees C (+40 to +140 degrees F)

(2) Accuracy: +/-1 degreeC (2 degreesF) over the operating range.

(3) Drift: Maximum 1 degreeC (2 degreesF) per year.

d. Outside Air Temperature

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NOTE: Designer must choose a range for outside air sensors suitable to the environment at the project site.
****

(1) Operating Range: [__] to [__] degreesC ([__] to [__] degreesF)

(2) Accuracy:

(a) +/-1 degreeC (2 degreesF) over the range of -35 to +55 degreesC (-30 to +130 degrees F)

(b) +/-0.5 degreeC (1 degreeF) over the range of -1 to +40 degreesC (+30 to +100 degrees F)

(3) Drift: Maximum 0.5 degreesC (1 degreeF) per year

e. High Temperature Hot Water

(1) Operating Range: +65 to +232 degreesC (+150 to +450 degreesF)

(2) Accuracy: +/-1 degreeC (2 degreesF)

(3) Drift: Maximum +/-1 degreeC (2 degreesF) per year

f. Chilled Water

(1) Operating Range: -1 to +38 degreesC (+30 to +100 degreesF)

(2) Accuracy: +/-0.4 degreeC (0.8 degreesF) over the range of +2 to +16 degreesC (+35 to +60 degreesF) and +/-1 degreeC (2 degreesF) over the rest of the operating range

(3) Drift: Maximum 0.4 degreeC (0.8 degreesF) per year

g. Dual Temperature Water

(1) Operating Range: -1 to +116 degreesC (+30 to +240 degreesF)

(2) Accuracy: +/-1 degreeC (2 degreesF) over the range of -1 to +116 degreesC (+30 to +240 degreesF)

(3) Drift: Maximum 1 degreeC (2 degreesF) per year

h. Heating Hot Water

(1) Operating Range: +21 to +121 degreesC (+70 to +250 degrees F)

(2) Accuracy: +/-1 degreeC (2 degreesF) over the range of +21 to +121 degreesC (+70 to +250 degrees F)

(3) Drift: Maximum 1 degreeC (2 degreesF) per year

i. Condenser Water

(1) Operating Range: -1 to +54 degreesC (+30 to +130 degreesF)

(2) Accuracy: +/-0.6 degreeC (1 degreeF) over the range of -1 to +54 degreesC (+30 to +130 degreesF)

(3) Drift: Maximum 0.6 degreeC (1 degreeF) per year

2.8.2.2 Point Temperature Sensors

Point Sensors shall be encapsulated in epoxy, series 300 stainless steel, anodized aluminum, or copper.

2.8.2.3 Averaging Temperature Sensors

Averaging sensors shall be a continuous element with a minimum length equal to 3m per square meter (1 foot per square foot) of duct cross-sectional area at the installed location. The sensing element shall have a bendable copper sheath.

2.8.2.4 Thermowells

Thermowells shall be Series 300 stainless steel with threaded brass plug and chain, 50mm (2inch) lagging neck and extension type well. Inside diameter and insertion length shall be as required for the application.

2.8.3 Relative Humidity Sensor

Relative humidity sensors shall use bulk polymer resistive or thin film capacitive type nonsaturating sensing elements capable of withstanding a saturated condition without permanently affecting calibration or sustaining damage. The sensors shall include removable protective membrane filters. Where required for exterior installation, sensors shall be capable of surviving below freezing temperatures and direct contact with moisture without affecting sensor calibration. When used indoors, the sensor shall be capable of being exposed to a condensing air stream (100% RH) with no adverse effect to the sensor's calibration or other harm to the instrument. The sensor shall be of the wall-mounted or duct-mounted type, as required by the application, and shall be provided with any required accessories. Sensors used in duct high-limit applications shall have a bulk polymer resistive sensing element. Duct-mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage.

Relative humidity (RH) sensors shall measure relative humidity over a range of 0% to 100% with an accuracy of +/-2%. RH sensors shall function over a temperature range of -4 to +55 degreesC (25 to 130 degreesF) and shall not drift more than 2% per year.

2.8.4 Differential Pressure Instrumentation

2.8.4.1 Differential Pressure Sensors

Differential Pressure Sensor range shall be as shown or as required for the application. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor. The accuracy shall be +/-2% of full scale.

2.8.4.2 Differential Pressure Switch

The switch shall have a user-adjustable setpoint. The setpoint shall not be in the upper or lower quarters of the range, and the upper limit of the range shall not be more than 3 times the setpoint. The over pressure rating shall be a minimum of 150% of the highest design pressure of either input to the sensor.

The switch shall have two sets of contacts and each contact shall have a volt-amp rating greater than it's connected load. Contacts shall open or close upon rise rise or drop of pressure above or below the setpoint as shown.

2.8.5 Flow Sensors

2.8.5.1 Airflow Measurement Array (AFMA)

AFMAs shall contain and airflow straightener if required by the AFMA manufacturer's published installation instructions. The straightener shall be contained inside a flanged sheet metal casing, with the AMFA located as specified according to the published recommendation of the AFMA manufacturer. In the absence of published documentation airflow straighteners shall be provided if there is any duct obstruction within 5 duct diameters upstream of the AFMA. Air-flow straighteners, where required, shall be constructed of 3mm (.125inch) aluminum honeycomb and the depth of the straightener shall not be less than 40mm (1.5inches).

The resistance to air flow through the airflow measurement station shall not exceed 20 Pa (0.08 inch water gauge) at an airflow of 10m/s (2,000fpm). AFMA construction shall be suitable for operation at airflows of up to 25m/s (5,000fpm) over a temperature range of +4 to +49 degreesC (+40 to +120 degreesF).

In outside air measurement or in low-temperature air delivery applications, the AFMA shall be certified by the manufacturer to be accurate as specified over a temperature range of [-29 to +49 degreesC (-20 to +120 degreesF)][___].

a. Pitot Tube AFMA: Each Pitot Tube AFMA shall contain an array of velocity sensing elements. The velocity sensing elements shall be of the multiple pitot tube type with averaging manifolds. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published installation instructions of the AFMA manufacturer.

Pitot Tube AFMAs shall have an accuracy of +/-3% over a range of 2.5 to 12.5m/s (500 to 2,500fpm).

b. Electronic AFMA: Each electronic AFMA shall consist of an array of velocity sensing elements. The velocity sensing elements shall be of the resistance temperature detector (RTD) or thermistor type, providing a temperature compensated (from 0 to 100 degreesC) output. The sensing elements shall be distributed across the duct cross section in the quantity and pattern specified by the published application data of the AFMA manufacturer.

****
NOTE: Ensure that outside air temperature range is appropriate for the environment at the project site, and provide a range if it's not.
****

Electronic AFMAs shall have an accuracy of +/-3% percent over a range of 0.6 to 12.5 m/s (125 to 2,500 fpm).

2.8.5.2 Orifice Plate

Orifice plate shall be made of an austenitic stainless steel sheet of 3.3mm (0.125inch) nominal thickness with an accuracy of +/-1% of full flow. The orifice plate shall be flat within 0.1mm (0.002inches). The orifice surface roughness shall not exceed 0.5micrometers (20microinches). The thickness of the cylindrical face of the orifice shall not exceed 2% of the pipe inside diameter or 12.5% of the orifice diameter, whichever is smaller. The upstream edge of the orifice shall be square and sharp. Where orifice plates are used, concentric orifice plates shall be used in all applications except steam flow measurement in horizontal pipelines.

2.8.5.3 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel with an accuracy of +/-1% of full flow. The inlet nozzle form shall be elliptical and the nozzle throat shall be the quadrant of an ellipse. The thickness of the nozzle wall and flange shall be such that distortion of the nozzle throat from strains caused by the pipeline temperature and pressure, flange bolting, or other methods of installing the nozzle in the pipeline shall not cause the accuracy to degrade beyond the specified limit. The outside diameter of the nozzle flange or the design of the flange facing shall be such that the nozzle throat shall be centered accurately in the pipe.

2.8.5.4 Venturi Tube

Venturi tube shall be made of cast iron or cast steel and shall have an accuracy of +/-1% of full flow. The throat section shall be lined with austenitic stainless steel. Thermal expansion characteristics of the lining shall be the same as that of the throat casting material. The surface of the throat lining shall be machined to a +/-1.2 micrometer (50microinch) finish, including the short curvature leading from the converging entrance section into the throat.

2.8.5.5 Annular Pitot Tube

Annular pitot tube shall be averaging type differential pressure sensors with four total head pressure ports and one static port made of austenitic stainless steel. Sensor shall have an accuracy of +/-2% of full flow and a repeatability of +/-0.5% of measured value.

2.8.5.6 Insertion Turbine Flowmeter

Insertion Turbine Flowmeter accuracy shall be +/-1% of reading for a minimum turndown ratio of 1:1 through a maximum turndown ratio of 50:1. Repeatability shall be +/-0.25% of reading. The meter flow sensing element shall operate over a range of ambient to 187 degreesC (370 degreesF) with a pressure loss limited to 1% of operating pressure at maximum flow rate. Design of the flowmeter probe assembly shall incorporate integral flow, temperature, and pressure sensors. The turbine rotor assembly shall be constructed of Series 300 stainless steel and use teflon seals.

2.8.5.7 Vortex Shedding Flowmeter

Vortes Shedding Flowmeter accuracy shall be within +/-0.8% of the actual flow. The flow meter body shall be made of austenitic stainless steel. The vortex shedding flowmeter body shall not require removal from the piping in order to replace the shedding sensor.

2.8.5.8 Positive Displacement Flow Meter

The flow meter shall be a direct reading, gerotor, nutating disk or vane type displacement device rated for liquid service as shown. A counter shall be mounted on top of the meter, and shall consist of a non-resettable mechanical totalizer for local reading, and a pulse transmitter for remote reading. The totalizer shall have a six digit register to indicate the volume passed through the meter in litersgallons, and a sweep-hand dial to indicate down to 1 litergallon The pulse transmitter shall have a hermetically sealed reed switch which is activated by magnets fixed on gears of the counter. The meter shall have a bronze body with threaded or flanged connections as required for the application. Output accuracy shall be +/-2% of the flow range. The maximum pressure drop at full flow shall be 34kilopascals (5psig).

2.8.5.9 Flow Meters, Paddle Type

Sensor shall be non-magnetic, with forward curved impeller blades designed for water containing debris. Sensor accuracy shall be +/-2% of rate of flow, minimum operating flow velocity shall be 0.3 meters per second (1 foot per second). Sensor repeatability and linearity shall be +/-1%. Materials which will be wetted shall be made from non-corrosive materials and shall not contaminate water. The sensor shall be provided with isolation valves and shall be rated for installation in pipes of 76mm to 1m (3 to 40inch) diameters. The transmitter housing for shall be a NEMA 250 Type 4 enclosure.

2.8.5.10 Flow Switch

Flow switch shall have a repetitive accuracy of +/-10% of actual flow setting. Switch actuation shall be adjustable over the operating flow range. The switch shall have Form C snap-action contacts, rated for the application. The flow switch shall have non flexible paddle with magnetically actuated contacts and be rated for service at a pressure greater than the installed conditions. Flow switch for use in sewage system shall be rated for use in corrosive environments encountered.

2.8.5.11 Gas Utility Flow Meter

Gas utility flow meter shall be diaphragm or bellows type (gas positive displacement meters) for flows up to 19.7 liters/sec (2500 SCFH) and axial flow turbine type for flows above 19.7 liters/sec (2500 SCFH), designed specifically for natural gas supply metering, and rated for the pressure, temperature, and flow rates of the installation. Meter shall have a minimum turndown ratio of 10 to 1 with an accuracy of +/-1% of actual flow rate. The meter index shall include a direct reading mechanical totalizing register and electrical impulse dry contact output for remote monitoring. The electrical impulse dry contact output shall provide not less than 1 pulse per 3 cubic meters (100 cubic feet) of gas and shall require no field adjustment or calibration. The highest electrical impulse rate available from the manufacturer, not exceeding 10 pulses per second for the installed application, shall be provided.

2.8.6 Electrical Instruments

Electrical Instruments shall have a range as shown or suitable for the application.

2.8.6.1 Watt or Watthour Transducers

Watt transducers shall measure voltage and current and shall output kW, kWh, or kW and kWh as shown. kW outputs shall have an accuracy of +/-0.25% over a power factor range of .1 to 1. kWh outputs shall be a pulse output and shall have an accuracy of +/-0.25% over a power factor range of .1 to 1.

2.8.6.2 Watthour Revenue Meters

Watthour revenue meters shall measure voltage and current and shall be in accordance with ANSI C12.1 and have pulse initiators for remote monitoring of Watthour consumption. Pulse initiator shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1.

2.8.6.3 Watthour Revenue Meter with Demand Register

Meters shall measure voltage and current and shall be in accordance with ANSI C12.1 and shall have pulse initiators for remote monitoring of Watthour consumption and instantaneous demand. Pulse initiators shall consist of form C contacts with a current rating not to exceed two amperes and voltage not to exceed 500 V, with combinations of VA not to exceed 100 VA, and a life rating of one billion operations. Meter sockets shall be in accordance with ANSI C12.1

2.8.6.4 Current Transducers

Current transducers shall accept an AC current input and shall have an accuracy of +/-0.25% of full scale. An integral power supply shall be provided if required for the analog output signal. The device shall have a means for calibration.

2.8.6.5 Current Sensing Relays

Current sensing relays (CSRs) shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, noninductive.

Current sensing relays shall be of split-core design. The CSR shall be rated for operation at 200% of the connected load. Voltage isolation shall be a minimum of 600 volts. The CSR shall autocalibrate to the connected load.

2.8.6.6 Voltage Transducers

Voltage transducers shall accept an AC voltage input and have an accuracy of +/-0.25% of full scale. An integral power supply shall be provided if required for the analog output signal. The device shall have a means for calibration. Line side fuses for transducer protection shall be provided.

2.8.7 pH Sensor

The sensor shall be suitable for applications and chemicals encountered in water treatment systems of boilers, chillers and condenser water systems. Construction, wiring, fittings and accessories shall be corrosion and chemical resistant with fittings for tank or suspension installation. Housing shall be polyvinylidene fluoride with O-rings made of chemical resistant materials which do not corrode or deteriorate with extended exposure to chemicals. The sensor shall be encapsulated. Periodic replacement shall not be required for continued sensor operation. Sensors shall use a ceramic junction and pH sensitive glass membrane capable of withstanding a pressure of 689 kilopascals at 66 degreesC (100 psig at 150 degreesF). The reference cell shall be double junction configuration. Sensor range shall be 0 to 12 pH, stability 0.05, sensitivity 0.02, and repeatability of +/-.05 pH value, response of 90% of full scale in one second and a linearity of 99% of theoretical electrode output measured at (24 degreesC) (76 degreesF).

2.8.8 Oxygen Analyzer

Oxygen analyzer shall consist of a zirconium oxide sensor for continuous sampling and an air-powered aspirator to draw flue gas samples. The analyzer shall be equipped with filters to remove flue air particles. For boiler applications, sensor probe temperature rating shall be 435 degreesC (815 degreesF). The sensor assembly shall be equipped for flue flange mounting.

2.8.9 Carbon Monoxide Analyzer

Carbon monoxide analyzer shall consist of an infrared light source in a weather proof steel enclosure for duct or stack mounting. An optical detector/analyzer in a similar enclosure, suitable for duct or stack mounting shall be provided. Both assemblies shall include internal blower systems to keep optical windows free of dust and ash at all times. The third component of the analyzer shall be the electronics cabinet. Automatic flue gas temperature compensation and manual/automatic zeroing devices shall be provided. Unit shall read parts per million (ppm) of carbon monoxide in the range of [___] to [___] ppm and the response time shall be less than 3 seconds to 90% value. Repeatability shall be +/-2% of full scale with an accuracy of +/-3% of full scale.

2.8.10 Occupancy Sensors

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NOTE: Do not use occupancy sensors with instant start fluorescent ballasts for instant start of

lamps because they shorten the lamp life by at least 20 percent. Use only rapid start fluorescent ballasts.

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NOTE: Show which type of occupancy sensor to use drawings: Ultrasonic sensors are best suited for spaces with partitions or dividers; Infrared sensors are best suited in line-of-sight applications.

Show occupancy sensor mounting location on drawings. Office furniture is less likely to interfere with (block) ceiling or wall-mount sensors. In retrofit applications, occupancy sensors can be installed in place of existing light switches.

Dual-technology sensors (one sensor incorporating both types) ordinarily turn lighting ON when both technologies sense occupancy. Then, detection by either technology will hold lighting ON.

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Occupancy sensors shall have occupancy-sensing sensitivity adjustment and an adjustable off-delay timer with a range encompassing 30 seconds to 15 minutes. Occupancy sensors shall be rated for operation in ambient air temperatures ranging from 10 degrees C (50 degrees F) to 40 degreesC (104 degrees F) or temperatures normally encountered in the installed location. Dual-technology occupancy sensors consisting of PIR and ultrasonic sensors are permissible unless otherwise specified or shown. Dual-technology occupancy sensors consisting of PIR and ultrasonic sensors shall be used where shown. Sensors integral to wall mount on-off light switches shall have an auto-off switch. Wall switch sensors shall be decorator style and shall fit behind a standard decorator type wall plate. All occupancy sensors, power packs, and slave packs shall be U.L. listed.

In addition to any outputs required for lighting control, the occupancy sensor shall provide a contact output rated at 1A at 24VAC or a SNVT output.

2.8.10.1 Passive Infrared (PIR) Occupancy Sensors

PIR occupancy sensors shall have a multi-level, multi-segmented viewing lens and a conical field of view with a viewing angle of 180 degrees and a range from the sensor of no less than 6 meters (20 feet) unless otherwise shown or specified. PIR Sensors shall provide field-adjustable background light-level adjustment with an adjustment range suitable to the light level in the sensed area, room or space. PIR sensors shall be immune to false triggering from RFI and EMI.

2.8.10.2 Ultrasonic Occupancy Sensors

Ultrasonic sensors shall operate at a minimum frequency 32 kHz and shall be designed to not interfere with hearing aids

2.8.11 Vibration Switch

Vibration switch shall be solid state, enclosed in a NEMA 250 Type 4 or Type 4X housing with sealed wire entry. Unit shall have two independent sets of Form C switch contacts with one set to shutdown equipment upon excessive vibration and a second set for monitoring alarm level vibration. The vibration sensing range shall be a true rms reading, suitable for the application. The unit shall include either displacement response for low speed or velocity response for high speed application. The frequency range shall be at least 2 Hz to 200 Hz. Contact time delay shall be 3 seconds. The unit shall have independent start-up and running delay on each switch contact. Alarm limits shall be adjustable and setpoint accuracy shall be +/-10% of setting with repeatability of plus or minus 2%.

2.8.12 Conductivity Sensor

Sensor shall include local indicating meter and shall be industrial grade and suitable for measurement of conductivity of water in boilers, chilled water systems, condenser water systems, distillation systems, or potable water systems as shown. Sensor shall sense from 0 to 10 microSeimens per centimeter (uS/cm) for distillation systems, 0 to 100 uS/cm for boiler, chilled water, and potable water systems and 0 to 1000 uS/cm for condenser water systems. Contractor shall field verify the ranges for particular applications and adjust the range as required. Contractor shall submit a complete water quality analysis of a sample of the process to be monitored with the submittal of the sensor manufacturer's catalog data. The transmitter shall provide a temperature compensated (from 0 to 100 degreesC) output. The accuracy shall be +/-2% of the full scale reading. Sensor shall have automatic zeroing and shall require no periodic maintenance or recalibration.

2.8.13 Compressed Air Dew Point Sensor

Sensor shall be industrial grade and suitable for measurement of dew point from -40 to +27 degreesC. (-40 to +80 degrees F). The transmitter shall provide both dry bulb and dew point temperatures on separate outputs. The end to end accuracy of the dew point shall be +/-2.8 degreesC (+/-5 degreesF) and the dry bulb shall be +/-0.6 degreeC (+/-1 degreeF). Sensor shall be automatic zeroing and shall require no normal maintenance or periodic recalibration. Sensor shall be rated for up to 1 megapascals (150 psig) service.

2.8.14 Refrigerant Leakage Monitor

Refrigerant Leakage Monitor shall be suitable for measurement of the specific refrigerant in use in the area monitored. Sensor shall measure the specified refrigerant at concentrations less than exposure limits required by ASHRAE 15. If multiple pickups are required according to ASHRAE 15, a multi-zone system shall be provided. If multiple refrigerants are used, separate modules specifically adjusted for each monitored refrigerant shall be provided. The monitor shall provide an output from the worst case zone and shall have a local LCD indication in ppm, and local indicators indicating leakage detected, alarm level detected, sensor trouble and normal operation for each zone and for each refrigerant. The alarm level indication and the leakage level indication shall be visual and audible locally, with a silence button. The alarm level detected and leakage detected indications shall be activated based on local adjustable setpoints marked in ppm and shall close separate Form C contacts for local safety interlocks. Sensor shall have automatic zeroing and shall require perioduc maintenance or recalibration.

2.8.15 NOx Monitor

Monitor shall continuously monitor and give local indication of boiler stack gas for NOx content. It shall be a complete system designed to verify compliance with the Clean Air Act standards for NOx normalized to a 3% oxygen basis and shall have a range of from 0 to 100 ppm. Sensor shall be accurate to +/-5 ppm. Sensor shall an output of NOx and oxygen levels and a dry alarm contact that closes when above a locally adjustable NOx setpoint. Sensor shall have normal, trouble and alarm lights. Sensor shall have heat traced lines if the stack pickup is remote from the sensor. Sensor shall be complete with automatic zero and span calibration using a timed calibration gas system, and shall require no normal calibration. Panel shall be powered from 120 VAC, single phase, 60 Hz.

2.8.16 Turbidity Sensor

Sensor shall include a local indicating meter and shall be industrial grade and suitable for measurement of turbidity of water. Sensor shall sense from 0 to 1000 Nephelometric Turbidity Units (NTU). Range shall be field-verified for the particular application and adjusted as required. The transmitter shall provide a temperature compensated (from 0 to 100 degreesC) output. The accuracy shall be +/-5% of full scale reading. Sensor shall have automatic zeroing and shall require no normal maintenance or periodic recalibration. Sensor shall be powered by a 120 VAC, single phase, 60 Hz power source.

2.8.17 Chlorine Detector

The detector shall measure concentrations of chlorine in water in the range 0 to 20 ppm with a repeatability of +/-1% of full scale and an accuracy of +/-2% of full scale. The transmitter shall be housed in a noncorrosive NEMA 250 Type 4X enclosure. Detector shall include a local panel with adjustable alarm trip level, local audio and visual alarm with silence function.

2.8.18 Floor Mounted Leak Detectors

Leak detectors shall use electrodes mounted at slab level with either a minimum time delay of 0.5 seconds or a minimum built-in-vertical adjustment of 3mm (0.125 inches) to prevent activation due to high humidity. Detector shall have a contact rating of 1.0 amps resistive or 200 mA inductive at 28 Vdc. The indicator shall be manual reset type.

2.8.19 Aquastat

Aquastats shall be of the strap on type, with 5 degreesC (10 degreesF) fixed deadband and an accuracy of +/-2 degreesC (3.6 degreesF) and shall incorporate a user-adjustable setpoint..

2.8.20 Freezestats

Freezestats shall be manual reset, low temperature safety switches with a minimum element length of 3m per square meter (1foor per square foot) of duct cross-sectional area at the installed location which shall respond to the coldest 450mm (18inch) segment with an accuracy of +/-2 degreesC (3.6 degreesF). The switch shall have a user-adjustable setpoint with a range of at least -1 to +10 degreesC (+30 to +50 degreesF).

The switch shall have two sets of contacts and each contact shall have a volt-amp rating greater than it's connected load. Contacts shall open or close upon rise rise or drop of temperature above or below the setpoint as shown, and shall remain in this state until reset.

2.8.21 Damper End Switches

****
NOTE: If the HVAC system design includes smoke dampers in the return air and fan discharge, or other dampers requiring end switches, show the end switches on drawings.
****

Each end switch shall be a hermetically sealed switch with a trip lever and over-travel mechanism. The switch enclosure shall be suitable for mounting on the duct exterior and shall permit setting the position of the trip lever that actuates the switch. The trip lever shall be aligned with the damper blade.

2.8.22 DUCT SMOKE DETECTORS

Duct smoke detectors shall:

a. conform to the requirements of UL 268A

b. have perforated sampling tubes

c. be rated for air velocities that include air flows between [2.5 and 20m/s (500 and 4000ft/min)][_____m/s (_____ft/min)].

d. have a minimum of two independent sets of contacts, one normally-open (NO) and one normally-closed (NC). The NC contact shall be rated for a 120VAC starter circuit.

e. upon detecting smoke in the duct, the NO contact shall close and the NC contact shall open and both sets of contacts shall remain in this state until reset via a manual reset.

2.9 INDICATING DEVICES

All indicating devices shall display readings in metric (SI)English (inch-pound) units.

2.9.1 Thermometers

Thermometers shall not contain mercury. Thermometers shall have an accuracy of +/-1% of scale range. Thermometers shall have a range suitable for the application with an upper end of the range not to exceed 150% of the design upper limit.

2.9.1.1 Piping System Thermometers

Piping system thermometers shall have brass, malleable iron or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 230mm (9inch) scale. Thermometers for piping systems shall have rigid stems with straight, angular, or inclined pattern. Thermometer stems shall have expansion heads as required to prevent breakage at extreme temperatures. On rigid-stem thermometers, the space between bulb and stem shall be filled with a heat-transfer medium.

2.9.1.2 Air-Duct Thermometers

Air-duct thermometers shall have perforated stem guards and 45-degree adjustable duct flanges with locking mechanism.

2.9.2 Pressure Gauges

Gauges shall be suitable for field or panel mounting as required, shall have black legend on white background, and shall have a pointer traveling through a 270-degree arc. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be +/-3% of scale range. Gauges shall meet requirements of ASME B40.1.

2.9.3 Low Differential Pressure Gauges

Gauges for low differential pressure measurements shall be a minimum of 90 mm (3.5 inch) (nominal) size with two sets of pressure taps, and shall have a diaphragm-actuated pointer, white dial with black figures, and pointer zero adjustment. Gauge range shall be suitable for the application with an upper end of the range not to exceed 150% of the design upper limit. Accuracy shall be plus or minus two percent of scale range.

2.10 OUTPUT DEVICES

Output Devices with SNVT input are ASCs and shall meet all ASC reqruirements in addition to the output device requirements.

2.10.1 ACTUATORS

****

NOTE: Include the appropriate bracketed text if pneumatic actuators are used.

Edit the control Schematic drawing to show electric and/or pneumatic actuators along with their failsafe positions (NO, NC, or fail-in-last-position (FILP)). See the UFC for design guidance on choosing actuator fail-to positions.

****

****

NOTE: Include the bracketed text if using electric actuator position feedback. This should be limited to primary equipment, such as built-up air handlers. Show this feedback signal on the control schematic drawings or specifically state where this requirement applies. Add the actuator position to the Point Schedule as a network variable available to be monitored by the UMCS (present or future).

****

Actuators shall be electric (electronic) [or pneumatic as shown]. All actuators shall be normally open (NO), normally closed (NC) or fail-in-last-position as shown. Normally open and normally closed actuators shall be of mechanical spring return type. Electric actuators shall have an electronic cut off or other means to provide burnout protection if stalled. Actuators shall have a visible position indicator. [Electric actuators shall provide position feedback to the controller as shown.] Actuators shall smoothly open or close the devices to which they are applied. Pneumatic actuators shall have a full stroke response time matching the connected Electric to Pneumatic Transducers (EP). Electric actuators shall have a full stroke response time of 90 seconds or less at rated load. Electric actuators shall be of the foot-mounted type with an oil-immersed gear train or the direct-coupled type. Where multiple electric actuators operate from a common signal, the actuators shall provide an output signal identical to its input signal to the additional devices. [Pneumatic actuators shall be rated for 172kPa (25psi) operating pressure except for high-pressure cylinder-type actuators.]

2.10.1.1 Valve Actuators

****

NOTE: Indicate in the Valve Schedule a close-off pressure that is 150% of the pump dead head pressure for 2-way valves and 150% of the pump differential pressure for 3-way valves, or equivalent torque values.

****

Valve actuators shall provide shutoff pressures and torques as shown on the Valve/Damper Schedule.

2.10.1.2 Damper Actuators

Damper actuators shall provide a minimum of 250% of the motive power necessary to operate the damper over its full range of operation. The actuator torque shall not be less than 1.4N-m (12inch-pounds) per 929 square centimeter (1 square foot) of damper area in both directions of actuator travel.

2.10.1.3 Positive Positioners

****

NOTE: Only larger valves and actuators or where high-speed actuation is needed may require positive positioners. Edit the drawings to show positive positioners when they are required. The typical drawings do not show/require them due to maintenance requirements for these devices. See UFC 3-410-02 for more information.

****

Positive positioners shall be a pneumatic relay with a mechanical position feedback mechanism and an adjustable operating range and starting point.

2.10.2 Solenoid-Operated Electric to Pneumatic Switch (EPS)

Solenoid-Operated Electric to Pneumatic Switches (EPS) shall accept a voltage input to actuate its air valve. Each valve shall have three-port operation: common, normally open, and normally closed. Each valve shall have an outer cast aluminum body and internal parts of brass, bronze, or stainless steel. The air connection shall be a 10mm (0.38inch) NPT threaded connection. Valves shall be rated for 345kPa (50psig) when used in a control system that operates at 172kPa (25psig) or less, or 1035kPa (150psig) when used in a control system that operates in the range of 172 to 690kPa (25 to 100psig).

2.10.3 Electric to Pneumatic Transducers (EP)

****

NOTE: Depending on the application, the designer may choose to select an EP and actuator combination to operate over the full range in less than 90 seconds.

****

Electric to Pneumatic Transducers (EPs) shall convert either a 4-20mADC input signal, a 0-10V input signal, or SNVT input to a 21-103kPa (3-15psig) pneumatic output with a conversion accuracy of +/-2% of full scale, including linearity and hysteresis. The EP shall withstand pressures at least 150% of the system supply air pressure (main air). EPs shall include independent offset and span adjustment. Air consumption shall not be greater than 0.024L/s (0.05 scfm). EPs shall have a manual adjustable override for the EP pneumatic output. EPs shall have sufficient output capacity to provide fullrange stroke of the actuated device in both directions within [90][___] seconds.

2.10.4 Relays

Control relay contacts shall have utilization category and ratings selected for the application, with a minimum of two sets of contacts enclosed in a dustproof enclosure. Each set of contacts shall incorporate a normally open (NO), normally closed (NC) and common contact. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.11 USER INPUT DEVICES

User Input Devices with SNVT output shall be considered Application Specific Controllers and meet all requirements thereof in addition to the user input device requirements.

2.11.1 Potentiometer

The Potentiometer shall be of the thumb wheel or sliding bar type and shall be clearly labeled for increase or decrease or it's output.

2.11.2 Switch

Switches shall be clearly labeled in a permanent fashion to show their intended function.

2.11.3 Momentary Contact Push-Button

Momentary Contact Push-Buttons may include an adjustable timer for their output.

2.12 MULTIFUNCTION DEVICES

Multifunction devices are products which combine the functions of multiple sensor, user input or output devices into a single product. Unless otherwise specified, the multifunction device shall meet all requirements of each component device. Where the requirements for the component devices conflict, the multifunction device shall meet the most stringent of the requirements.

2.12.1 Current Sensing Relay Command Switch

The Current Sensing Relay portion shall meet all requirements of the Current Sensing Relay input device. The Command Switch portion shall meet all requirements of the Relay output device except that it shall have at least one normally-open (NO) contact.

2.12.2 Thermostats

Thermostats shall be multifunction devices incorporating a temperature sensor and a temperature display.

In addition, the thermostat shall have the following as specified and shown:

a. A User Input Device which shall adjust a temperature setpoint output.

b. A User Input Momentary Contact Button and an output indicating zone occupancy.

c. A three position User Input Switch labeled with 'HEAT', 'COOL', and 'OFF' positions ('HEAT-COOL-OFF' switch)and corresponding outputs.

d. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and corresponding outputs.

e. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and corresponding outputs.

2.13 COMPRESSED AIR STATIONS

****

NOTE: The designer will estimate the required control air consumption to calculate the required motor horsepower of the control air compressor and coordinate with the electrical designer.

For hospitals and critical installations, a standby compressor will be provided. For all other applications, the portion covering standby compressor will be deleted. For hospitals, delete the Contractor option permitting the use of polyethylene tubing in lieu of copper.

Indicate on the drawings the locations where metallic raceway or electric metallic tubing is not required for protection of nonmetallic tubing.
****

2.13.1 Air Compressor Assembly

The air compressor shall be a high pressure compressing unit with electric motor. The compressor shall be equipped with a motor with totally enclosed belt guard, an operating-pressure switch, safety relief valves, gauges, intake filter and intake silencer, and combination type magnetic starter with undervoltage protection and thermal-overload protection for each phase, and shall be supported by a steel base mounted on an air storage tank. The air compressor shall provide the compressed air required for control operation while operating not more than one-third of the time. The air storage tank shall be fabricated for a working pressure of not less than 1380kPa (200psi), and constructed and certified in accordance with ASME BPVC SEC VIII D1. The tank shall be of sufficient volume so that no more than six compressor starts per hour are required with the starting pressure switch differential set at 140kPa (20psi). The tank shall be provided with an automatic condensate drain trap with manual override feature. [A second (duplex arrangement) compressor of capacity equal to the primary compressor shall be provided, with interlocked control to provide automatic changeover upon malfunction or failure of either compressor. A manual selector switch shall be provided to index the lead compressor including the automatic changeover.]

2.13.2 Compressed Air Station Specialties

2.13.2.1 Refrigerated Dryer, Filters and, Pressure Regulator

A refrigerated dryer shall be provided in the air outlet line of the air storage tank. The dryer shall be of the size required for the full delivery capacity of the compressor. The air shall be dried at a pressure of not less than 483kPa (70psi) to a temperature not greater than 2 degrees C (35 degrees F). The dryer shall be provided with an automatic condensate drain trap with manual override feature. The automatic drain trap shall have an adjustable cycle and drain time. The refrigerant used in the dryer shall be one of the fluorocarbon gases and have an Ozone Depletion Potential of not more than 0.05. A five micron prefilter and coalescing-type 0.03 micron oil removal filter with shut-off valves shall be provided in the dryer discharge. Each filter bowl shall be rated for 1034kPa (150psi) maximum working pressure. A pressure regulator, with high side and low side pressure gauges, and a safety valve shall be provided downstream of the filter. Pressure regulators of the relieving type shall not be used.

2.13.2.2 Flexible Pipe Connections

The flexible pipe connections shall be designed for 1034kPa and 120 degrees C (150psi and 250 degrees F) service, and shall be constructed of rubber, tetrafluoroethylene resin, or braided corrosion-resistant steel, bronze, monel, or galvanized steel. The connectors shall be suitable for the service intended and shall have threaded or soldered ends. The length of the connectors shall be as recommended by the manufacturer for the service intended.

2.13.2.3 Vibration Isolation Units

The vibration isolation units shall be standard products with published loading ratings, and shall be single rubber-in-shear, double rubber-in-shear, or spring type.

2.14 DIRECT DIGITAL CONTROL (DDC) HARDWARE

2.14.1 General Requirements

All DDC Hardware shall meet the following requirements:

a. It shall incorporate a "service pin" which, when pressed will cause the DDC Hardware to broadcast its 48-bit NodeID and its ProgramID over the network. The service pin shall be distinguishable and accessible.

b. It shall incorporate a light indicating power.

c. It shall incorporate a TP/FT-10 transceiver in accordance with ANSI/EIA-709.3 and connections for TP/FT-10 control network wiring. It shall not have connections to any other media type

d. It shall communicate on the network using only the ANSI/EIA-709.1B protocol.

****

NOTE: FYI, a link powered device gets it's power from the communication cable as opposed to from a separate power source.

****

e. It shall be locally powered, link powered devices are not acceptable.

f. LonMark external interface files (XIF files) as defined in the LonMark XIF Guide shall be submitted for each type of DDC hardware.

g. Application program shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration parameter settings.

h. It shall have all functionality specified and required to support the Sequence of Operation and application in which it is used, including but not limited to:

(1) It shall provide input and output SNVTs as specified and required to support the sequence and application in which it is used.

(2) It shall be configurable via standard or user-defined configuration parameters (SCPT) or hardware settings on the controller itself specified and as required to support the sequence and application in which it is used.

i. It shall meet FCC Part 15 requirements and have UL 916 or equivalent safety listing.

2.14.2 Hardware Input-Output (I/O) Functions

DDC Hardware incorporating hardware input-output (I/O) functions shall meet the following requirements:

a. Analog Inputs: DDC Hardware analog inputs (AIs) shall perform analog to digital (A-to-D) conversion with a minimum resolution of 12 bits plus sign. Signal conditioning including transient rejection shall be provided for each analog input. Analog inputs shall be individually calibrated for zero and span, in hardware or in software. The AI shall incorporate common mode noise rejection of 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of 20 dB at 60 Hz from a source impedance of 10,000 ohms.

b. Analog Outputs: DDC Hardware analog outputs (AOs) shall perform digital to analog (D-to-A) conversion with a minimum resolution of 12 bits plus sign, and output a signal within the range of 4-20mADC or 0-10VDC. Analog outputs shall be individually calibrated for zero and span.

c. Binary Inputs: DDC Hardware binary inputs (BIs) shall accept contact closures and shall ignore transients of less than 5 milli-second duration. Isolation and protection against an applied steady-state voltage up to 180VAV peak shall be provided.

d. Binary Outputs: DDC Hardware binary outputs (BOs) shall provide relay contact closures or triac outputs for momentary and maintained operation of output devices.

(1) Relay Contact Closures: Closures shall have a minimum duration of 0.1 second. BO relays shall provide at least 180V of isolation. Electromagnetic interference suppression shall be furnished on all output lines to limit transients to nondamaging levels. Minimum contact rating shall be one ampere at 24VAC.

(2) Triac outputs: Triac outputs shall provide at least 180V of isolation.

e. Pulse Accumulator: DDC Hardware pulse accumulators shall have the same characteristics as the BI. In addition, a buffer shall be provided to totalize pulses. The pulse accumulator shall accept rates up to 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

2.14.3 Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (ie ProgramID) with configurable settings. ASCs shall meet the following requirements in addition to the general DDC Hardware and DDC Hardware Input-Output (I/O) Function requirements:

a. ASCs shall be LonMark Certified.

b. All necessary configuration parameters for the sequence and application in which the ASC is used shall be fully configurable through an LNS plug-in. This plug-in shall be submitted for each ASC installed as specified. (Note that sensors and actuators fully configurable through hardware settings do not not require a plug-in)

2.14.3.1 Local Display Panel (LDP)

The Local Display Panel shall be a wall-mountable Application Specific Controller with a display and navigation buttons. It shall have SNVT inputs which an operator can select to display, and SNVT outputs which the operator can both display and change the value of.

2.14.4 General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) is not installed with a fixed factory-installed application program. GPPCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Function :

a. The programmed GPPC shall conform to the LonMark Interoperability Guide.

b. All programming software required to program the GPPC shall be submitted as specified.

c. Copies of the installed GPPC application programs in machine readable form compatible with the supplied programming software shall be submitted as specified. The submitted GPPC application program shall be the complete application necessary for the GPPC to function as installed.

PART 3 EXECUTION

3.1 PROJECT TIMING

TABLE I: PROJECT TIMING specifies the sequencing and timing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3: EXECUTION (denoted by an 'E' in the 'TYPE' column).

a. Timing for submittals: The timing specified for submittals is the deadline by which the submittal shall be initially submitted to the government. Following submission there will be a government review period as specified in Section 01330 SUBMITTAL PROCEDURES. If the submittal is not accepted by the government, the contractor shall revise the submittal and resubmit it to the government within [14][__] days of notification that the submittal has been rejected. Upon resubmittal there shall be an additional government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Timing for Activities: The timing specified for activities indicates the earliest the activity may begin.

TABLE I. PROJECT TIMING

ITEM	TYPE	DESCRIPION	START OF ACTIVITY or DEADLINE FOR SUBMITTAL

TABLE I. PROJECT TIMING

ITEM	TYPE	DESCRIPION	START OF ACTIVITY or DEADLINE FOR
1	S	Design Drawings	
2	S	Manufacturers Catalog Data	
3	S	Network Bandwidth Calculations	
4	E	Install DDC System	after approval of 1,2,3
5	E	Start-Up and Testing	after 4
6	S	Start-Up and Testing Report	[15] days after 5
7	S	Draft As-Built Drawings	[15] days after 5
8	S	PVT Procedures	[30] days before scheduled start of 9 and after approval of 6
9	E	Perform PVT	after approval of 6,7,8
10	S	PVT Report	[15] days after 9
11	S	Preventive Maintenance Work Plan	after approval of 1,2,3
12	S	Training Documentation	after approval of 1,2,3
13	S	Programming Software	after approval of 1,2,3
14	S	XIF Files	after approval of 1,2,3
15	S	LNS Plug-ins	after approval of 1,2,3
16	S	GPPC Application Programs	[15] days after 9
17	E	Training	after approval of 11,12,13
18	S	Final As-Built Drawings	[15] days after 17
19	S	O&M Manual	[15] days after 17
20	S	LNS Database	[15] days after 17

3.2 CONTROL SYSTEM INSTALLATION

3.2.1 General Installation Requirements

3.2.1.1 HVAC Control System

The HVAC control system shall be completely installed, tested and ready for operation. Dielectric isolation shall be provided where dissimilar metals are used for connection and support. Penetrations through and mounting holes in the building exterior shall be made watertight. The HVAC control system installation shall provide clearance for control system maintenance by maintaining access space between coils, access space to mixed-air plenums, and other access space required to calibrate, remove, repair, or replace control system devices. The control system installation shall not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.2.1.2 Device Mounting Criteria

Devices mounted in or on piping or ductwork, on building surfaces, in mechanical/electrical spaces, or in occupied space ceilings shall be installed in accordance with manufacturer's recommendations and as shown. Control devices to be installed in piping and ductwork shall be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Strap-on temperature sensing elements shall not be used except as specified. Spare thermowells shall be installed adjacent to each thermowell containing a sensor and as shown. Devices located outdoors shall have a weathershield.

3.2.1.3 Labels and tags

Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings. In mechanical rooms, all enclosures and DDC hardware shall be labeled, and all sensors and actuators shall be tagged. Each terminal unit shall be labeled or tagged. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Duct static pressure taps shall be tagged at the location of the pressure tap. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures shall be engraved plastic. Labels inside protective enclosures may attached using adhesive, but shall not be hand written.

3.2.2 DDC Hardware

DDC Hardware shall be installed in an enclosure. Where multiple pieces of DDC Hardware are used to execute one sequence, all DDC Hardware executing that sequence shall be on a local control bus containing that DDC Hardware only and connected to another local control bus via an ANSI-709.1 Router or ANSI-709.3 repeater as specified.

3.2.3 Local Display Panel (LDP)

****

NOTE: Designer must indicate on each points schedule which points, if any, are to be displayed or adjustable from an LDP.

****

Local Display Panels shall be installed [in each mechanical room containing an air handler][___] and shall provide SNVT inputs for dispay and outputs for adjusting SNVT values as shown on the Points Schedule. Multiple LDPs installed in the same mechanical room shall be co-located and clearly labelled indicating which SNVTs they provide access to.

3.2.4 Gateways

****

NOTE: The intent of this is to allow the use of gateways to packaged equipment controllers, not to allow the installation of a non-ANSI 709.1 network connected to a 15951 ANSI 709.1 network via a gateway.

****

Gateways may be used for communication with non-ANSI/EIA-709.1 control hardware subject to all of the following limitations:

a. Each gateway shall communicate with and perform protocol translation for non-ANSI/EIA-709.1 control hardware controlling one and only one package unit.

b. Non-ANSI/EIA-709.1 control hardware shall not be used for controlling built-up units.

c. The non-ANSI/EIA-709.1 control hardware shall not perform system scheduling functions.

3.2.5 Network Interface Jack

****
NOTE: Choose the number of interface cables to be furnished by the Contractor.
****

A standard network interface jack shall be provided within 3m (10ft) of each node on the control network except terminal unit controllers with hardwired thermostats. For terminal unit controllers with hardwired themostats, the network interface jack should shall be located at the thermostat, but may be provided within 3m (10ft) of the node. If the network interface jack is other than an 1/8inch phone jack, Contractor shall provide an interface cable with a standard 1/8inch phone jack on one end and a connector suitable for mating with installed network interface jack on the other. No more than one type of interface cable shall be required to access all network interface jacks. Contractor shall furnish [1][___] interface cable.

3.2.6 Room Instrument Mounting

****
NOTE: Wall mounted thermostats and similar control system components containing user input devices in ADA compliant facilities and spaces are required to be mounted 1.2 meters (48 inches) above the floor for forward reach and 1.3 meters (54 inches) for side reach. Note the mounting height and location for these system components on the drawings or revise the following paragraph accordingly.
****

Room instruments, such as wall mounted thermostats, shall be mounted 1.5m (60inches) above the floor unless otherwise shown.

3.2.7 Indication Devices Installed in Piping and Liquid Systems

Gauges in piping systems subject to pulsation shall have snubbers. Gauges for steam service shall have pigtail fittings with cock. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

3.2.8 Duct Smoke Detectors

****
NOTE: Duct detectors are intended to shut down air distribution fans and smoke dampers if provided. Each detector will be indicated on the schematic and associated ladder diagram. When duct smoke detectors which are remote from the associated fans are required, such as those required in air systems over 7 cubic meters/ second (15,000 cfm) serving more than one story, the location of all duct detectors shall be indicated on the plans as well as on the schematic and ladder diagrams.

When the building is equipped with a fire alarm system, the detectors will be connected to the fire alarm control panel (FACP) for alarm initiation. Drawings will indicate wiring to the fire alarm control panel. For existing alarm systems, the designer must detail the connection to the FACP. Duct mounted smoke detectors will need auxiliary contacts to interface with HVAC Control Panel. Coordinate with Section 16721 FIRE DETECTION AND ALARM SYSTEM.

****

Duct smoke detectors shall be provided in supply and return air ducts in accordance with NFPA 90A. Duct Smoke Detector circuitry shall be mounted in a metallic enclosure exterior to the duct and shall have perforated sampling tubes extended into the air duct. Detectors shall be [locally powered][powered from the fire alarm control panel (FACP] and connected to the FACP for alarm initiation]. A manual reset switch shall be provided at the detector for detectors that are located less than eight feet above the finished floor and readily visible. Other detectors shall be provided with a readily visible remote annunciation lamp and readily accesible reset switch. Remote lamps and switches as well as the affected fan units shall be properly identified in etched rigid plastic placards.

3.2.9 Occupancy Sensors

A sufficient quantity of occupancy sensors shall be provided to provide complete coverage of the area (room or space). Occupancy sensors shall be installed in accordance with NFPA 70 requirements and the manufacturer's instructions. Occupancy sensors shall not be located within 6 to 8 feet of HVAC outlets or heating ducts. PIR and dual-technology PIR/ultrasonic sensors shall not be installed where they can "see" beyond any doorway. Ultrasonic sensors shall not be installed in spaces containing ceiling fans. Sensors shall turn on the lights (load) within 2 feet after occupant enters the room and shall not trigger ON from movement seen outside the room through doors or through windows. The off-delay timer shall be set to 15 minutes unless otherwise shown. All sensor adjustments shall be made prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc. Each controlled area shall have one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

3.2.10 Freezestats

For each 2 square meters (20 square feet) of coil face area, or fraction thereof, a freezestat shall be provided to sense the temperature at the location shown. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily. The freezestat sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.

3.2.11 Averaging Temperature Sensing Elements

Sensing elements shall be installed in a serpentine pattern located as shown.

3.2.12 Air Flow Measurement Arrays (AFMA))

****
NOTE: Air filters are specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION AND EXHAUST SYSTEMS and installed by the Mechanical Contractor (not by the controls contractor under this spec).
****

****
NOTE: If MinOA ducts are not used do not permit pitot tube AFMA for OA measurement (keep bracketed text).
****

Outside Air AFMAs shall be located downstream from the Outside Air filters. Pitot Tube AFMA shall not be used if the expected velocity measurement is below 3.5 m/s (700 fpm)[or for outside airflow measurements].

3.2.13 Duct Static Pressure Sensors

The duct static pressure sensing tap shall be located at 75% to 100% of the distance between the first and last air terminal units. If the transmitter is wired in a homerun configuration to an AHU controller, the transmitter shall be located in the same enclosure as the air handling unit (AHU) controller(s) for the AHU serving the terminal units.

3.2.14 Flowmeters

The minimum straight unobstructed piping for the flowmeter installation shall be at least 10 pipe diameters upstream and at least 5 pipe diameters downstream and in accordance with the manufacturer's installation instructions.

3.2.15 Damper Actuators

Actuators shall not be mounted in the air stream. Multiple actuators shall not be connected to a common drive shaft. Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

3.2.16 Damper Installation

Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error. Blades shall close completely and leakage shall not exceed that specified at the rated static pressure. Structural support shall be used for multi-section dampers. Acceptable methods include but are not limited to U-channel, angle iron, corner angles and bolts, bent galvanized steel stiffeners, sleeve attachments, braces, and building structure. Where multi-section dampers are installed in ducts or sleeves, they shall not sag due to lack of support. Jackshafts shall not be used to link more than three damper sections. Blade to blade linkages shall not be used.

Outside and return air dampers shall be installed such that their blades direct their respective air streams towards each other to provide for maximum mixing of air streams.

3.2.17 Local Gauges for Actuators

Pneumatic actuators shall have an accessible and visible pressure gauge installed in the tubing lines at the actuator as shown.

3.2.18 Wiring Criteria

Wiring shall be installed without splices between control devices. Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the contractor shall be tested as specified in IEEE Std 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR and as shown.

Wiring external to enclosures shall be run as follows:

a. Wiring other than low-voltage control and low-voltage network wiring shall be installed in raceways and in accordance with NFPA 70

b. Low-voltage control and low-voltage network wiring not in suspended ceilings over occupied spaces shall be installed in raceways, except that nonmetallic-sheathed cables or metallic-armored cables may be installed in accordance with NFPA 70

c. Low-voltage control and low-voltage network wiring in suspended ceilings over occupied spaces shall be installed in raceways, except:

(1) nonmetallic-sheathed cables or metallic-armored cables may be installed in accordance with NFPA 70

(2) plenum rated cable in suspended ceilings over occupied spaces may be run without raceways

3.2.19 Copper Tubing

Copper tubing shall be hard-drawn in exposed areas and either hard-drawn or annealed in concealed areas. Only tool-made bends shall be used. Fittings for copper tubing shall be brass or copper solder joint type except at connections to apparatus, where fittings shall be brass compression type.

3.2.20 Plastic Tubing

Plastic tubing shall be run within covered raceways or conduit except when otherwise specified. Plastic tubing shall not be used for applications where the tubing could be subjected to a temperature exceeding 55 degreesC (130 degreesF). Fittings for plastic tubing shall be for instrument service and shall be brass or acetal resin of the compression or barbed push-on type.

Except in walls and exposed locations, plastic multitube instrument tubing bundle without conduit or raceway protection may be used where a number of air lines run to the same points, provided the multitube bundle is enclosed in a protective sheath, is run parallel to the building lines and is adequately supported as specified.

3.2.21 Pneumatic Lines

Pneumatic lines shall be installed such that they are not exposed to outside air temperatures. Pneumatic lines shall be concealed except in mechanical rooms and other areas where other tubing and piping is exposed. All tubes and tube bundles exposed to view shall be installed neatly in lines parallel to the lines of the building. Tubing in mechanical/electrical spaces shall be routed so that the lines are easily traceable.

Air lines shall be purged of dirt, impurities and moisture before connecting to the control equipment. Air lines shall be number coded or color coded and keyed in the As-Built Drawings for future identification and servicing the control system.

3.2.21.1 Pneumatic Lines in Mechanical/Electrical Spaces

In mechanical/electrical spaces, pneumatic lines shall be plastic or copper tubing. Horizontal and vertical runs of plastic tubing or soft copper tubing shall be installed in raceways or rigid conduit dedicated to tubing. Dedicated raceways, conduit, and hard copper tubing not installed in raceways shall be supported every 2m (6feet) for horizontal runs and every 2.5m (8feet) for vertical runs.

3.2.21.2 Pneumatic Lines External to Mechanical/Electrical Spaces

****

NOTE: Delete protective sheath for nonmetallic tubing in concealed, accessible areas not subject to abuse.

****

Tubing external to mechanical/electrical spaces shall be soft copper with sweat fittings or plastic tubing in raceways not containing power wiring. Raceways and tubing not in raceways shall be supported every 2.5m (8 feet). Pneumatic lines concealed in walls shall be hard-drawn copper tubing or plastic tubing in rigid conduit. Plastic tubing in a protective sheath, run parallel to the building lines and supported as as specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.2.21.3 Terminal Single Lines

Terminal single lines shall be hard-drawn copper tubing, except when the run is less than 300mm (12in) in length, flexible polyethylene may be used.

3.2.21.4 Connection to Liquid and Steam Lines

****

NOTE: The designer will select tubing and fitting and fitting materials appropriate for the ductwork and piping services. Stainless steel tubing will only be used when required for the application such as in corrosive atmospheres.

****

Tubing for connection of sensing elements and transmitters to liquid and steam lines shall be [copper][Series 300 stainless steel] with [brass compression][stainless-steel compression] fittings.

3.2.21.5 Connection to Ductwork

Connections to sensing elements in ductwork shall be plastic tubing.

3.2.21.6 Tubing in Concrete

Tubing in concrete shall be installed in rigid conduit. Tubing in walls containing insulation, fill, or other packing materials shall be installed in raceways dedicated to tubing.

3.2.21.7 Tubing Connection to Actuators

Final connections to actuators shall be plastic tubing 300mm (12 inches) long and unsupported at the actuator.

3.2.22 Compressed Air Stations

The air compressor assembly shall be mounted on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. The air line shall be connected to the tank with a flexible pipe connector. Compressed air station specialties shall be installed with required tubing, including condensate tubing to a floor drain. Compressed air stations shall deliver control air meeting the requirements of ISA S7.0.01.

****
NOTE: If possible, foundations and housekeeping pads should be specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION AND EXHAUST SYSTEMS.
****

Foundations and housekeeping pads shall be provided for the HVAC control system air compressors[in accordance with the air compressor manufacturer's instructions][as specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION AND EXHAUST SYSTEMS].

3.3 DRAWINGS AND CALCULATIONS

Contractor shall prepare and submit shop drawings.

3.3.1 Network Bandwidth Usage Calculations

The Contractor shall perform Building Control Network Bandwidth Usage Calculations for a normally loaded and a heavily loaded control network. Calculations shall be performed for network traffic on the backbone.

A heavily loaded control network is characterized as one performing the following activities simultaneously:

a. Transmitting every point in the building indicated on Points Schedules as being available to the UMCS in response to polling requests at 15-minute intervals (for trending at UMCS).

b. Transmitting five points to the UMCS in response to polling requests at 2-second intervals.

c. Transmitting 100 points to the UMCS in response to polling requests at 5-second intervals.

d. Transmitting occupancy commands from the UMCS to every system schedule sequence in a one-minute interval.

e. Transmitting occupancy override commands from the UMCS to every system schedule sequence in a one-minute interval.

A normally loaded control network is characterized as one performing the following activities simultaneously:

a. Transmitting every point in the building indicated on Points Schedules as requiring a trend to the UMCS in response to polling requests at 15-minute intervals (for trending at UMCS).

b. Transmitting 50 points to the UMCS in response to polling requests at 5-second intervals.

c. Tranmitting occupancy commands from the UMCS to every system scheduler sequence in a one-minute interval.

3.3.2 DDC Contractor Design Drawings

****
NOTE: Designer must decide whether to require a specific drawing size (approx 11x17 or 22x34) or to leave it up the the contractor.
****

Drawings shall be on [ISO A1 (841 by 594mm) or 34 by 22inches][or][A3(420 by 297mm) or 17 by 11inches] sheets in the form and arrangement shown. The drawings shall use the same abbreviations, symbols, nomenclature and identifiers shown. Each control system element on a drawing shall be assigned a unique identifier as shown. The HVAC Control System Drawings shall be delivered together as a complete submittal. Deviations shall be approved by the Contracting Officer.

a. HVAC Control System Drawings shall include the following:

(1) Drawing Index, HVAC Control System Legend.

(2) Valve Schedule, Damper Schedule.

(3) Compressed Air Station Schematic.

(4) Rider diagram of building control network.

(5) Control System Schematic and Points Schedule for each system.

(6) Sequences of Operation including Control Logic Diagrams for each system.

(7) Controller Wiring Diagrams for each system.

(8) Motor Starter and Relay Wiring Diagram for each system.

b. The HVAC Control System Drawing Index shall show the name and number of the building, military site, State or other similar designation, and Country. The Drawing Index shall list HVAC Control System Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The HVAC Control System Legend shall show and describe all symbols and abbreviations shown on the HVAC Control System Drawings.

c. The valve schedule shall include each valve's unique identifier, size, flow coefficient Kv (Cv), pressure drop at specified flow rate, spring range, positive positioner range, actuator size, close-off pressure ot torque data, dimensions, and access and clearance requirements data. The valve schedule shall contain actuator selection data supported by calculations of the force required to move and seal the valve, access and clearance requirements. Valve schedules may be submitted in advance but shall be included in the complete submittal.

d. The damper schedule shall contain each damper's unique identifier, nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner ranges, locations of actuators and damper end switches, arrangement of sections in multi-section dampers, and methods of connecting dampers, actuators, and linkages. The Damper Schedule shall include the AMCA 500 maximum leakage rate at the operating static-pressure differential. Damper schedules may be submitted in advance but shall be included in the complete submittal.

e. The compressed air station schematic diagram shall show all equipment, including: compressor with motor horsepower and voltage; starter; isolators; manual bypasses; tubing sizes; drain piping and drain traps; reducing valves; dryer; and data on manufacturer's names and model numbers, mounting, access, and clearance requirements. Air Compressor and air dryer data shall include calculations of the air consumption of all electric-to-pneumatic transducers and of any other control system devices to be connected to the compressed air station, and the compressed air supply dewpoint temperature at 140kPa (20psig). Compressed air station schematic drawings shall be submitted for each compressed air station.

f. The control system schematics shall be in the form shown, and shall show all control and mechanical devices associated with the system. A system schematic drawing shall be submitted for each system.

g. The HVAC control system Points Schedule shall be as shown. All DDC Hardware shall be referenced in a Points Schedule. A Points Schedule shall be submitted for each HVAC system.

h. The HVAC control system sequence of operation shall reflect the language and format of this specification, and shall refer to the devices by their unique identifiers as shown. No operational deviations from specified sequences will be permitted without prior written approval of the Government. Sequences of operation shall be submitted for each HVAC control system including each type of terminal unit control system.

i. The controller wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to controller and to the identified terminals of devices input and output, starters and package equipment. The wiring diagrams shall show necessary jumpers and ground connections. The wiring diagrams shall show the labels of all conductors. Sources of power required for control systems and for packaged equipment control systems shall be identified back to the panel board circuit breaker number, controller enclosures, magnetic starter, or packaged equipment control circuit. Each power supply and transformer not integral to a controller, starter, or packaged equipment shall be shown. The connected volt-ampere load and the power supply volt-ampere rating shall be shown. Wiring diagrams shall be submitted for each control system.

j. The Riser Diagram of the Building Control Network shall show all network cabling, DDC Hardware, and Network Hardware including:

(1) Room number locations of all enclosures containing DDC hardware

(2) All DDC hardware with room number locations

(3) DDC hardware unique identifiers and common descriptive names

(4) All Network hardware room number locations

(5) Network hardware unique identifiers

(6) All cabling with media types labeled

(7) Room number location of all cabling termination points

(8) Room number location of all TP/FT-10 network access jacks

(9) Locations of all user interfaces including OWS and LDPs.

3.3.3 Draft As-Built Drawings

The contractor shall update the Contractor Design Drawings with all as-built data and submit as specified.

3.3.4 Final As-Built Drawings

The contractor shall update the Draft As-Built Drawings with all final as-built data and submit as specified.

3.4 HVAC SYSTEMS SEQUENCES OF OPERATION

Unless otherwise specified, all modulating control applications shall use proportional-integral (PI) control.

3.4.1 Alarm Handling

****

NOTE: Alarm handling is generally performed by the Monitoring and Control (M&C) software (Section 13801). The alarm handling described here is for redundant notification of critical alarms. These are alarms which must be received even if the UMCS/front-end is not functioning/present.

Choose the required functionality for the alarm handling notification, indicate which alarms are critical/require a redundant notification on the Points Schedule and indicate routing for these alarms (which notification method is to be used for which alarm, and who is to be notified) on the Alarm Routing Schedule.
****

The contractor shall install and configure DDC hardware to provide alarm handling functionality for critical alarms as specified and shown, either in a piece of DDC Hardware dedicated to this function or in DDC Hardware performing other functions. The DDC Hardware providing alarm handling functionality shall provide the following capabilities as require:

a. Dial to a pager: The node shall be able to dial a paging service and leave a numeric message.

[b. Dial to an email server: The node shall be able to dial and connect to a remote server and send an email via SMTP.]

[c. Send email over IP Network: The alarm handling node shall be capable of connecting to an IP network and send email via SMTP.]

[d. Provide network access: The node shall be capable of receiving a connection via the modem to allow a remote computer access to the control network.]

3.4.2 Scheduling

****
NOTE: Scheduling is normally performed by the Monitoring and Control (M&C) software (Section 13801). The UMCS (13801) contractor will set this up. In the absence of a UMCS or if communication with the UMCS is lost, a default schedule will be active.

The M&C software will have capabilities to perform scheduling according to day of week, holidays, etc and will have the capability to override system occupancy modes based on demand limiting programs or operator overrides.

Designer must indicate if Warm-Up-Cool-Down (WUCD) mode is applicable. If WUCD is to be used, keep bracketed references to WUCD and OC_STANDBY (and remove them otherwise).
****

3.4.2.1 System Mode

AHUs, VAVs, Fan Coils, and other terminal equipment shall operate in Occupied (OCC)[, Warm-Up-Cool-Down (WUCD),] or Unoccupied (UNOC) modes. Chillers, boilers, and other sources of heating/cooling for hydronic loads do not require scheduling; these systems receive requests for heating/cooling from their loads.

3.4.2.2 AHU System Scheduler Requirements

The Air Handling Unit (AHU) System Scheduler functionality shall reside in either a piece of DDC Hardware dedicated to this functionality or in the DDC Hardware controlling the system AHU. A single piece of DDC hardware may contain multiple System Schedulers. For each AHU and its associated terminal units, the Contractor shall provide, install, and configure the following AHU System Scheduler functionality:

a. Scheduled Occupancy Input: Accept SNVT of type SNVT_occupancy (as defined in the LonMark SNVT Master List). Input shall support the following possible values: [OC_STANDBY,]OC_OCCUPIED and OC_UNOCCUPIED.

b. Override Occupancy Input: Accept SNVT of type SNVT_occupancy (as defined in the LonMark SNVT Master List). Input shall support the following possible values: [OC_STANDBY,]OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL.

c. Terminal Unit Occupancy Inputs: Accept multiple inputs of SNVT type SNVT_Occupancy (as defined in the LonMark SNVT Master List) from Terminal Units or Terminal Unit Occupancy Sensors and be capable of distinguishing between them.

d. Air Handler Occupancy Output: Output one or more SNVTs indicating the desired AHU occupancy status as one of the following possible values: WUCD, Occupied and Unoccupied.

e. Terminal Unit Occupancy Output: Output one or more SNVTs indicating the desired AHU occupancy status as one of the following possible values: Occupied and Unoccupied.

****

NOTE: Designer must provide the default (backup) 24-hour 7-day schedule on the Points Schedule (i.e. Occupied from 6AM - 10PM Monday through Friday, Unoccupied Saturday and Sunday).

****

f. Default Schedule: It shall incorporate a 24-hour 7-day default schedule which may be activated and deactivated by the System Scheduler Logic.

g. Communication Determination: Determine time elapsed between receipts of the scheduled occupancy input, and use this elapsed time to activate and deactivate the 24-hour default schedule as specified.

3.4.2.3 System Scheduler Output Determination

a. AHU Occupancy Output: If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, the Scheduler AHU Occupancy output shall be determined by the default schedule. Otherwise, the System Scheduler AHU Occupancy output shall be determined as follows:

(1) If the Override Occupancy Input is not OC_NUL, the AHU Occupancy Output shall be the same as the Override Occupancy Input.

(a) The AHU Occupancy Output shall be Occupied when the Override Occupancy Input is OC_OCCUPIED.

(b) The AHU Occupancy Output shall be Unoccupied when the Override Occupancy Input is OC_UNOCCUPIED.

[

(c) The AHU Occupancy Output shall be WUCD when the Override Occupancy Input is OC_STANDBY.]

(2) If the Override Occupancy Input is OC_NUL and the Schedule Occupancy input is OC_OCCUPIED, the AHU Occupancy Output shall be OC_OCCUPIED.

(3) If the Override Occupancy Input is OC_NUL the Schedule Occupancy input is not OC_OCCUPIED, and less that [two][___] VAV Occupancy Inputs are OC_OCCUPIED, AHU Occupancy Output shall determined by the Scheduled Occupancy Input:

(a) The AHU Occupancy Output shall be Occupied when the Scheduled Occupancy Input is OC_OCCUPIED.

(b) The AHU Occupancy Output shall be Unoccupied when the Scheduled Occupancy Input is OC_UNOCCUPIED.

[

(c) The AHU Occupancy Output shall be WUCD when the Scheduled Occupancy Input is OC_STANDBY.]

(4) If the Override Occupancy Input is OC_NUL and [two][___] or more VAV Occupancy Inputs are OC_OCCUPIED, AHU Occupancy Output shall be Occupied.

b. Terminal Unit Occupancy Output: System Scheduler VAV Occupancy Output shall be determined as follows:

(1) Terminal Unit Occupancy Output shall be Occupied whenever the AHU Occupancy Output is Occupied.

(2) Terminal Unit Occupancy Output shall be Unoccupied whenever the AHU Occupancy Output is Unoccupied[or WUCD].

3.4.2.4 AHU Scheduling

The AHU Occupancy Output SNVT(s) shall be bound from the System Scheduler to the DDC Hardware that determes the AHU occupancy status.

3.4.2.5 Terminal Unit Scheduling

a. The Terminal Unit Occupancy Output SNVT shall be bound from the System Scheduler to all Terminakl Units in the same system.

b. Terminal Units shall have occupancy sensors as shown..

c. Terminal Units which depend on AHU service shall have their Effective Occupancy SNVT (of type SNVT_Occupancy) bound to a Terminal Unit Occupancy Input of the System Scheduler.

3.4.3 Perimeter Radiation Control Sequence

Operating mode shall be obtained from System Scheduler. If the operating mode is Occupied, the DDC Hardware shall modulate the perimeter heat valve to maintain zone temperature (measured from sensor located as shown) at an operator-adjustable setpoint. . If the operating mode is other than Occupied the perimeter heating valve shall be modulated to maintain the spcae temperature at the night setback setpoint.

3.4.4 Unit Heater and Cabinet Unit Heater

a. When the DDC Hardware places the Unit Heater in the Heating mode and the wall-mounted thermostat "AUTO-OFF" switch is in the "Auto" position, the fan shall be cycled to maintain its setpoint as shown.
b. When the switch is in the "OFF" position, the fan shall be stopped.

3.4.4.1 Alarms

The DDC Hardware shall monitor the alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.5 Gas-Fired Infrared Heater

Infrared heater controller shall have zone temperature sensor (located as shown), "Auto-Off" switch (located as shown), occupancy sensor as shown, and 2-position normally closed gas valve. When "Auto-Off" switch is in "Auto", the DDC Hardware shall cycle the gas valve to maintain setpoint. DDC Hardware shall incorporate operator-adjustable setpoint for "Occupied" mode and a configurable setpoint for "Unoccupied" mode.

3.4.6 Dual Temperature Fan-Coil Unit

****
NOTE: Revise this paragraph accordingly when 2-way valves are used in lieu of 3-way valves.

Select select either a local occupancy sensor or indicate that this system gets its occupancy from the System Scheduler via the network.
****

Controller shall have a space temperature sensor, an Occupant-adjustable setpoint input for Occupied mode, an auto-off switch located as shown [and occupancy sensor (located as shown).]

Based on the Occupancy mode , the DDC Hardware shall control to user-adjustable occupied setpoints or configurable unoccupied setpoints.

There shall be a deadband between the heating setpoint and the cooling setpoint (for both occupied setpoints and unoccupied setpoints).

System shall obtain its Operating Mode via the System Scheduler. If the operating mode (based on the availability of hot or chilled water) is Heating, the system shall control to heating setpoint, if operating mode is Cooling, system shall control to cooling setpoint. The DDC System shall cycle the multi-speed supply fan and 2-position [2-way][3-way] return water valve (with a deadband) to maintain zone setpoint.

3.4.6.1 Alarms

The DDC Hardware shall monitor alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.7 Central Plant Hydronic Heating with [Steam/Hot Water Converter][High Temperature Hot Water/Hot Water Heat Exchanger]

****

NOTE: This system assumes a manual start of system via Heating-Enable mode.

Designer shall modify as needed to use steam or high-temperature hot water.

Designer shall determine whether to have VSD on PHWP.

Design option will be shown below to permit automatic start of primary system via request for heating from secondary systems.

Designer should also determine whether to require a hardware OA-T sensor or to obtain the OA-T over the network.

****

[3.4.7.1 Primary Hot Water Pump ON/OFF Control:

PHWP control shall have a "HAND-OFF-AUTO" switch controlling the pump. When the switch is in "AUTO", the PHWP shall run if the OA-T is below a configurable setpoint (with a deadband) and the Heating Mode is Enabled. PHWP shall run with the H-O-A switch in "HAND." PHWP shall have proofs.]

[3.4.7.2 Primary Hot Water Pump Variable Speed Pumping Control:

PHWP control shall have a "HAND-OFF-AUTO" switch controlling the pump.

a. When the switch is in "AUTO":
   (1) PHWP shall run if the OA-T is below a configurable setpoint (with a deadband) and the Heating Mode is Enabled.
   (2) Otherwise the PHWP shall be off.
   (3) If the PHWP is running, the PHWP speed shall be modulated to maintain PHWP-P (from differential pressure sensor located as shown) at a configurable setpoint.

b. When the switch is in "HAND": PHWP shall run. PHWP speed shall be controlled via manual input located at the PHWP VFD. (This manual speed input shall be interlocked with "HAND-OFF-AUTO" switch.)

c. When the switch is in "OFF": HWP shall be Off. PWHP speed control loop shall be disabled.

PHWP shall have proofs.]

[3.4.7.3 Steam Valve Control:

When the PHWP is proofed, the steam valve shall be modulated to maintain PHW-S-T temperature (measured via sensor as shown) at setpoint. Temperature setpoint shall be computed via a linear reset schedule based OA-T. When the OA-T is [___] or below, PHW-T-SP shall be [_____]. When the OA-T is [____] or above, PHW-T-SP shall be [____]. If the PHWP is not proofed, steam valve shall close.]

[3.4.7.4 High-Temperature Hot Water Valve Control:

When the PHWP is proofed, the high-temperature hot water valve shall be modulated to maintain PHW-S-T temperature (measured via sensor as shown) at setpoint. Temperature setpoint shall be computed via a linear reset schedule based OA-T. When the OA-T is [___] or below, PHW-T-SP shall be [_____]. When the OA-T is [____] or above, PHW-T-SP shall be [____]. If the PHWP is not proofed, the high-temperature hot water valve shall close.]

The DDC Hardware shall monitor the safeties and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.8 Central Plant [Steam][High Temperature Hot Water] Dual-Temperature Hydronic

****
NOTE: Designer shall select Steam or High Temperature Hot Water as appropriate.
****

3.4.8.1 Hand-Off-Auto Switch

System shall incorporate a HOA switch.

3.4.8.2 Season (Heating/Cooling) Switch

System shall incorporate a Season (Heating/Cooling) switch.

3.4.8.3 Occupancy Mode

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied.

3.4.8.4 Pump Control Loop

PHWP shall run according to the H-O-A switch position:

a. When the switch is in "AUTO":Pump shall run if the outside air temperature is below a configurable setpoint (with a deadband) and the Season mode is Heating. If Occupied mode is Occupied and Season is Cooling and Return water temperature below a configurable setpoint the pump shall run. If Season is Cooling and return water temperature is greater than return water setpoint the pump shall run.

b. When the switch is in "Hand": Pump shall run.

c. When the switch is in "Off": Pump shall be Off.

PHWP shall have proofs.

3.4.8.5 Changeover Valves Control Loop

Subject to Safeties, when the Season is Heating the changeover valves shall open the system to the heat exchanger and close the system to the central plant chilled water. Subject to Safeties, when the Season is Cooling the changeover valves shall close the system to the heat exchanger and open the system to the central plant chilled water.

3.4.8.6 Heat Exchanger Valve Control Loop

When the Season is Heating and the pump has been proofed, the [steam][high temperature hot water] valve shall modulate to maintain the Hot Water Supply Temperature (from temperature sensor located as shown) at setpoint (otherwise, the [steam][high temperature hot water] valve shall be closed). The Hot Water Supply Temperature Setpoint shall determined from a linear reset schedule based on outside air temperature. When outside air temperature is [____] or below, the Hot Water supply temperature shall be [_____]. When outside air temperature is [____] or above, hot water supply temperature shall be [_____]. When this loop is disabled the Heat Exchanger Valve is closed.

3.4.8.7 Safeties

When the Season is indexed from Heating to Cooling the heat exchange valve control loop is disabled. The pump continues to run for cool-down. When the return water temperature falls to [ ] or below the changeover valves shall transfer water flow from the converter to the central-plant chilled-water system.

The DDC Hardware shall monitor the safeties and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.9 All-Air Small Package Unitary System

****

NOTE: Designer needs to select either a local occupancy sensor or indicate that this system gets its occupancy from the system scheduler via the network.

****

System shall incorporate a Hand-Off-Auto (HOA) switch (located as shown).

3.4.9.1 Occupancy and Zone Setpoint

Zone setpoint adjust [and Occupancy sensor] shall be located as shown. [Controller shall obtain occupancy information from the System Scheduler as shown.]

Controller shall have an occupant selectable Season (Heating/Cooling).

3.4.9.2 Zone Temperature Control Loop

Based on the Occupancy mode and Season mode, the zone temperature shall control the zone temperature to a user-adjustable or configurable occupied and unoccupied setpoints. There shall be a deadband between the heating setpoint and the cooling setpoint (for both occupied setpoints and unoccupied setpoints).

If HOA switch is OFF, fan and compressor shall be off.
If HOA switch is "HAND", fan shall be on. Otherwise, fan and compressor shall run subject to temperature control and Season mode shall be selected subject to temperature control as follows:

a. When the zone temperature is above zone cooling setpoint (with a deadband), fan and compressor shall run. Season mode shall be Cooling.

b. When the zone temperature is below zone heating setpoint (with a deadband), fan and compressor shall run. Season mode shall be Heating.

3.4.10 Single Building Dual-Temperature Hydronic

****

NOTE: Designers should be cautious when selecting the lower limit of hot water reset schedule. Selecting a limit too low could result in a return water temperature low enough to cause thermal shock or combustion chamber condensation in the boiler. In addition, because setpoint reset of system supply water temperature is achieved by bypassing water around the boiler, damage can occur to constant flow boilers. The use of a constant volume boiler loop as depicted in the UFC essentially eliminates these concerns. Delete references to boiler pumps in the subparagraphs below when not applicable for theproject.

****

3.4.10.1 Hand-Off-Auto and Heating/Cooling switches

Boiler and Chiller shall incorporate integral H-O-A switch and Season (Heating/Cooling) switch. When H-O-A switch is in Hand and Heating/Cooling Switch is in Heating, Boiler mode shall be Enabled. When H-O-A switch is in Hand and Season switch is in Cooling, Chiller Mode shall be Enabled. When H-O-A switch is in OFF, boiler and chiller mode shall be Disabled.

When H-O-A switch is in Auto, Boiler or Chiller Mode shall be Enabled or Disabled according to Occupancy Mode.

3.4.10.2 Occupancy Mode

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied.

3.4.10.3 Hot Water Setpoint Reset

As the outside air temperature falls the system hot water temperature setpoint shall be raised as shown.

3.4.10.4 Modulating Valve

When the boiler is enabled the modulating valve shall modulate the diverting valve to maintain system hot water temperature setpoint.

3.4.10.5 Chiller Enable

When the chiller is Enabled the chiller and pump shall be energized during the occupied mode, subject to safeties. At the conclusion of the occupied mode, the chiller shall be de-energized but the pump shall continue to circulate water for a period of time while the chiller completes its shutdown cycle, and then the pump shall stop.

3.4.10.6 Boiler Enable

When the Boiler Mode is Enabled by HOA and Season switches, the boiler and pump shall operate continuously subject to safeties whenever the outside-air temperature is low enough for the building to require heating. The boiler shall function under its own control system to maintain a constant boiler-water temperature.

3.4.10.7 Safeties

a. Index Heating to Cooling: hen the system is indexed from the heating mode to the cooling mode, the Boiler mode shall be Disabled. The pump shall continue to run to dissipate the heat from the piping system and the boiler until the return water temperature drops below the set point of the return-water thermostat. The changeover valves shall then close to the boiler and open to the chiller and the Chiller Enable shall be allowed to operate.

b. Index From Cooling to Heating: When the system is indexed from cooling to heating, the chiller shall enter its shutdown cycle and the pump shall continue to circulate water through the chiller for a period of time while the chiller completes its shutdown cycle. The changeover valves shall then close to the chiller and open to the boiler and the Boiler Enable shall be allowed to operate.

3.4.10.8 Alarms

The DDC Hardware shall monitor the safeties and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.11 Single Building Hydronic Heating with Hot Water Boiler

****
NOTE: Designers should be cautious when selecting the lower limit of hot water reset schedule. Selecting a limit too low could result in a return water temperature low enough to cause thermal shock or combustion chamber condensation in the boiler. The use of a constant volume boiler loop as depicted in the UFC essentially eliminates these concerns.
****

****
NOTE: This system assumes a manual start of system via Heating-Enable SNVT.

Designer shall determine whether to have VSD on HWP.

Design option will be shown below to permit automatic start of primary system via request for heating from secondary systems.

Designer should also determine whether to require a hardware OA-T sensor or to obtain the OA-T over the network.
****

[3.4.11.1 Hot Water Pump ON/OFF Control Loop:

Primary Hot Water Pump (PHWP) control shall have a "Hand-Off-Auto" switch controlling the pump. When the switch is in "Auto", the PHWP shall run if the outside air temperature is below a configurable setpoint (with a deadband) and the Heating Mode is Enabled. PHWP shall run with the H-O-A switch in Hand. PHWP shall have proofs.]

[3.4.11.2 Primary Hot Water Pump Variable Speed Pumping Control Loop:

PHWP control shall have a "Hand-Off-Auto" switch controlling the pump. When the switch is in Auto, the outside air temperature is below a configurable setpoint (with a deadband), and the Season Mode is Heating then the PHWP shall run. Otherwise the PHWP shall be off. If the PHWP is running, the PHWP speed shall be modulated to maintain differential pressure (sensed by differential pressure sensor located as shown) at a configurable setpoint.

a. When the switch is in "Hand": PHWP shall run. PHWP speed shall be controlled via manual input located at the PHWP VFD. (This manual speed input shall be interlocked with "Hand-Off-Auto" switch.)

b. When the switch is in "OFF": PHWP shall be Off. PHWP speed control loop shall be disabled.

PHWP shall have proofs.]

3.4.11.3 Boiler Control Loop

Boiler shall run (subject to internal boiler controls) when boiler pump is proven on.

3.4.11.4 Hydronic Heating Valve and Setpoint Reset Control:

When the PHWP is proofed, the heating control valve shall be modulated to maintain hot water supply temperature (measured via sensor as shown) at setpoint. Temperature setpoint shall be computed via a linear reset schedule based on outside air temeprature. When the outside air temperature is [___] or below, the hot water supply temperature setpoint shall be [_____]. When the outside air temperature is [____] or above, hot water supply setpoint shall be [____]. If the PHWP is not proofed, the primary hot water mixing valve shall be commanded to its normal position.

3.4.12 Heating and Ventilating Unit

****

NOTE: A special interlock control sequence for each fan system will be developed by the designer if required.

****

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proof does not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC Hardware. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

3.4.12.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to Fan Enable.

3.4.12.2 Occupancy Mode:

System shall obtain occupancy mode from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown]. System shall have Occupant adjustable setpoints for Occupied mode.

3.4.12.3 Fan and System Enable

All Modes: Fan Enable and all DDC Hardware control loops shall be subject to proof. Failure of proof shall result in all control loops being disabled, the fan being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The fan shall be commanded to run. The Zone Temperature Control Loop shall be enabled.

[Warm Up / Cool Down Mode: The supply fan shall be commanded to run. The Zone Temperature Control Loop shall be enabled

] Unoccupied mode: The supply fan shall be commanded off and the Zone Temperature Control Loop shall be disabled.

3.4.12.4 Zone Temperature Control:

When this loop is enabled, unit shall operate in either Cooling mode, Heating mode, or Minflow mode. Mode selection shall be based on difference between zone temperature as measured by sensor (as shown) and zone setpoint. When zone temperature is over setpoint plus a deadband, unit shall be in Cooling mode. When zone temperature is below setpoint minus a deadband, unit shall be Heating mode. When zone temperature is within a deadband of setpoint, unit shall be in Minflow mode.

a. COOLING MODE: The DDC hardware shall modulate the unit damper to maintain zone temperature at setpoint. Heating valve shall be closed.

b. MINFLOW MODE: The unit damper shall be be at its minimum position. Heating valve shall be closed.

c. HEATING MODE:The DDC hardware shall modulate the heating coil valve to maintain space temperature at setpoint. Damper shall be at its minimum position.

When Zone Temperature Control is disabled, heating valve shall be off and damper shall be fully closed.

3.4.12.5 Filter

The DDC Hardware shall monitor a differential pressure switch across the filter. The DDC Hardware shall initiate an alarm when the pressure drop across the filter reaches the setpoint.

3.4.12.6 Fan Proof and Safeties

Supply fan operation shall be subject to fan proof. Fan proof shall be monitored by DDC hardware. [Fan proof shall require a manual reset.]

3.4.12.7 Sub Title

The DDC Hardware shall monitor the [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.13 [Dual Duct] Multizone [with][without] Return Fan

****
NOTE: In a two-deck multizone system, given that there is no deadband between heating and cooling, reliable operation of the economizer cycle may be difficult to achieve. An economizer cycle should only be used in this system if the unit is either served by a dual-temp hydronic system, or HW and CHW availability is scheduled (i.e.- only HW is available during the heating season and vice versa). If HW and CHW are both available year-round, then an economizer cycle should not be used. The following sequence of operation should be edited accordingly.
****

****
NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proofs do not have manual reset. The designer needs to decide if in the event of shutdown due to fan proofs should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.
****

****

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

Edit as required for systems with/without return fans
****

3.4.13.1 Hand-Off-Auto switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to fan enable signal and safeties.

[Return fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, return fan shall run subject to safeties. When H-O-A switch is in OFF, return fan shall be off. When H-O-A switch is in AUTO, return fan shall run subject to Fan enable signal and safeties.]

3.4.13.2 Occupancy Mode:

System shall obtain occupancy from system scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.13.3 Fan and System Enable

All Modes: Fans and all DDC Hardware control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fans being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply [and return] fans shall be commanded to run. Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, Hot Deck Coil Control, Cold Deck Coil Control, and Zone Damper Control loops shall be enabled.

[
Warm Up / Cool Down: The supply [and return] fans shall be commanded to run. Mixed Air Temperature Control With Economizer, Hot Deck Coil Control, Cold Deck Coil Control, and Zone Damper Control loops shall be enabled. The Minimum Outside Air Flow Control loop shall be disabled.]

Unoccupied mode: The supply [and return] fans shall be cycled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. The Hot Deck Coil Control and Zone Damper Control loops shall be enabled. All other loops shall be disabled.

3.4.13.4 Hot Deck Coil Control

****
NOTE: Reset of the hot-deck discharge temperature setpoint should not be used in conjunction with outside air reset of the heating water supply temperature. If the heating water supply temperature setpoint is being reset based on outside air temperature, delete the related portions of this paragraph. Designer should choose the disabled position of the hot deck coil valve.
****

When this loop is enabled the DDC Hardware shall modulate the hot deck control valve based on the temperature of a sensing element located in the discharge air of the coil to maintain the setpoint [as shown].[The temperature setpoint shall be reset with a linear schedule based on the outside air temperature as shown.] When this loop is disabled, the hot deck coil valve shall be [open][closed].

3.4.13.5 Cold Deck Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the cold deck supply air temperature setpoint as shown. When this loop is disabled, the cooling coil valve shall be closed.

****
NOTE: When an economizer cycle is not to be used, delete this paragraph.
****

3.4.13.6 Mixed Air Temperature Control With Economizer

When this loop is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature setpoint as shown. When this loop is disabled or the Economizer is 'OFF', the economizer outside air and relief air dampers shall be closed.

3.4.13.7 Economizer Enable

The economizer shall be 'ON' when the outside air dry bulb temperature is between the high and low setpoints as shown.

3.4.13.8 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow setpoint as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.13.9 Zone Damper Control

When this loop is enabled the DDC Hardware shall modulate the zone mixing dampers to heat and cool their respective zones by mixing cold-deck air and hot-deck air to maintain their respective zone temperatures as measured by their respective sensors (as shown) at their respective setpoints (as shown).

3.4.13.10 Fan Proof and Safeties

Supply [and return] fan operation shall be subject to fan proofs and safeties as shown. Fan proofs and system safeties [and filter differential pressure switch] shall be monitored by DDC Hardware. Safeties shall be hardware interlocked to fan starter.

Supply fan status (proof) (SF-S)
[Return fan status (proof) (RF-S)]
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proofs and safeties shall require a reset via [local binary push-button input to the DDC] [local binary push-button input to the DDC Hardware or via remote command to the DDC Hardware from the OWS] [via remote command to the DDC Controller from the OWS].]

[Fan proofs shall require a reset via [local binary push-button input to the DDC Hardware] [local binary push-button input to the DDC Hardware or via remote command to the DDC Hardware from the OWS] [via remote command to the DDC Hardware from the OWS].]

3.4.13.11 Alarms

The DDC hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.14 Bypass Multizone with Return Fan

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proofs do not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

3.4.14.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to fan enable and safeties.

Return fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, return fan shall run subject to safeties. When H-O-A switch is in OFF, return fan shall be off. When H-O-A switch is in AUTO, return fan shall run subject to Fan enable signal and safeties.

3.4.14.2 Occupancy Mode:

System shall obtain occupancy from the System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.14.3 Fan and System Enable

All Modes: Fans and all DDC Hardware control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fans being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply and return fans shall be commanded to run. Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, Cold Deck Coil Control, and Zone Control loops shall be enabled.

[Warm Up / Cool Down: The supply and return fans shall be commanded to run. Mixed Air Temperature Control With Economizer, Cold Deck Coil Control, and Zone Control loops shall be enabled. The Minimum Outside Air Flow Control loop shall be disabled.]

Unoccupied mode: The supply and return fans shall be cycled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. All control loops shall be disabled.

3.4.14.4 Cold Deck Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the cold deck supply air temperature setpoint as shown. When this loop is disabled, the cooling coil valve shall be closed.

3.4.14.5 Mixed Air Temperature Control With Economizer

When this loop is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature setpoint as shown. When this loop is disabled or the Economizer is 'OFF', the economizer outside air and relief air dampers shall be closed.

3.4.14.6 Economizer Enable

The economizer shall be 'ON' when the outside air dry bulb temperature is between the high and low setpoints as shown.

3.4.14.7 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow setpoint as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.14.8 Zone Damper Control

When this loop is enabled the DDC Hardware shall modulate the zone mixing dampers to heat and cool their respective zones by mixing cold-deck air and bypass-deck air to maintain their respective zone temperatures as measured by their respective sensors (as shown) at their respective setpoints (as shown).

3.4.14.9 Fan Proof and Safeties

Supply and return fan operation shall be subject to fan proofs and safeties as shown. Fan proofs and system safeties shall be monitored by DDC Hardware. Safeties shall be hardware interlocked to fan [VFD][starter].

Supply fan status (proof) (SF-S)
Return fan status (proof) (RF-S)
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proofs and safeties shall require a manual reset.]

3.4.14.10 Alarms

The DDC Hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.15 Variable Air Volume Control Sequence [with][without] Return Fan

****
NOTE: Edit as necessary for systems with/without

return fan.

NOTE: Designer must select variable frequency drive (VFD) or starter with inlet guide vanes for fan capacity modulation. If VFDs are selected the designer must specify a VFD that meets the requirements of the control sequence including the integral H-O-A and a safety shutdown input circuit that is separate from the start/stop input.

NOTE: Minimum outside air flow control can be accomplished one of four different ways. Refer to the UFC.

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset, and the reset button (RST-BUT) local to the DDC panel is pressed. The fan proofs and duct static pressure safety device do not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof or high duct static, should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you specify an OWS and associated software, show the necessary SNVTs on the Points Schedule, and edit the sequence and control logic diagram.

NOTE: The inclusion of filter pressure switches should be coordinated with the local O&M staff. Pressure switches may not be desired/needed, particularly if filters are replaced on a regular schedule. Edit the drawings as required.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project. In the event of shutdown due to smoke the system will remain shutdown until the smoke detector is reset and the reset button (RST-BUT) local to the DDC panel is pressed. The RST-BUT requirement can be deleted, but will require

editing of the sequence and the control logic diagram. While fan shutdown is accomplished using a smoke detector contact hardwired directly to the supply fan, a LonWorks Emergency mode shutdown SNVT (input to each AHU and VAV controller) is also available, but is not specified here and its use should be coordinated with other applicable specifications, local requirements, and codes.
****

3.4.15.1 Hand-Off-Auto switches

Supply fan [VFD][starter] shall have an [integral] H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to fan enable signal and safeties.

[Return fan [VFD][starter] shall have an [integral] H-O-A switch. When H-O-A switch is in HAND, return fan shall run subject to safeties. When H-O-A switch is in OFF, return fan shall be off. When H-O-A switch is in AUTO, return fan shall run subject to fan enable signal and safeties.]

3.4.15.2 Occupancy Mode:

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.15.3 Fan and System Enable

All Modes: AHU's serving series fan-powered VAV box fans shall start prior to starting the AHU fan that serves the VAV boxes. Fans and all DDC Hardware control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fans being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply [and return] fans shall be commanded to run. The Supply Duct Static Pressure Control, [Return Fan Volume Control], Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, and Cooling Coil Control loops shall be enabled.

[Warm Up / Cool Down: The supply [and return] fans shall be commanded to run. The Supply Duct Static Pressure Control, [Return Fan Volume Control], Mixed Air Temperature Control With Economizer, and Cooling Coil Control loops shall be enabled. The Minimum Outside Air Flow Control loop shall be disabled.]

Unoccupied mode: The supply [and return] fans shall be cycled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. The Supply Duct Static Pressure Control [and Return Fan Volume Control] shall be enabled. All other loops shall be disabled.

3.4.15.4 Supply Duct Static Pressure Control

When this loop is enabled the DDC Hardware shall modulate the supply fan variable frequency drive unit to maintain the duct static pressure at setpoint (as shown) as measured by the duct static pressure tap and sensor as shown. When this loop is disabled, the output to the [VFD][inlet guide vanes] shall be zero percent.

[3.4.15.5 Return Fan Volume Control

When this loop is enabled the DDC Hardware shall modulate the return fan [variable frequency drive unit] [inlet guide vanes] to maintain a constant volumetric airflow difference at setpoint (as shown) as measured by the airflow measurement arrays located in the supply and return ducts as shown. When this loop is disabled, the output to the [VFD][inlet guide vanes] shall be zero percent.]

3.4.15.6 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow setpoint as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.15.7 Mixed Air Temperature Control With Economizer

When this loop is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature setpoint as shown. When this loop is disabled or the Economizer is 'OFF', the economizer outside air and relief air dampers shall be closed.

3.4.15.8 Economizer Enable

The economizer shall be 'ON' when the outside air dry bulb temperature is between the high and low setpoints as shown.

3.4.15.9 Cooling Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain the supply air temperature setpoint as shown. When this loop is disabled, the cooling coil valve shall be closed.

3.4.15.10 Fan Proof and Safeties

Supply [and return] fan operation shall be subject to fan proofs and safeties as shown. Fan proofs and system safeties shall be monitored by DDC Hardware. Safeties shall be hardware interlocked to fan [VFD][starter].

Supply fan status (proof) (SF-S)
[Return fan status (proof) (RF-S)]
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air duct pressure high limit (SA-P-HL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proofs and safeties shall require a manual reset.]

[Fan proofs and supply air duct pressure high limit shall require a reset via [local binary push-button input to the DDC] [local binary push-button input to the DDC Hardware or via remote command to the DDC Hardware from the OWS] [remote command to the DDC Hardware from the OWS].]

3.4.15.11 Alarms

The DDC Hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.16 Single Zone with Hydronic Heating and Dual Temperature Coil Without Return Fan

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proof does not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

3.4.16.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to fan enable signal and safeties.

3.4.16.2 Occupancy Mode

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: OCCUPIED, UNOCCUPIED[, or WarmUp/CoolDown].

3.4.16.3 Heating/Cooling Mode

Heating or Cooling mode shall be determined from temperature sensor in the dual-temperature water supply.

3.4.16.4 Fan and System Enable

All Modes: Fan and all control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fan being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply fan shall be commanded to run. The Minimum Outside Air Control, Setpoint Reset Control, Mixed Air Temperature Control With Economizer, and the Dual Temperature Heating/Cooling Coil Control loops shall be enabled.

[Warm Up / Cool Down: The supply fan shall be commanded to run. Setpoint Reset Control, Mixed Air Temperature Control With Economizer, and Heating/Cooling Coil Control loops shall be enabled. The Minimum Outside Air Control loop shall be disabled.]

Unoccupied mode: The supply fan shall be cycled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. The Dual Temperature Heating/Cooling Coil Control shall be enabled. All other loops shall be disabled.

3.4.16.5 Dual Temperature Heating/Cooling Coil Control

When this loop is enabled the DDC Hardware shall modulate the dual temperature coil valve to maintain space temperature.

3.4.16.6 Mixed Air Temperature Control With Economizer

****
NOTE: Designer should choose difference between supply air setpoint and mixed air setpoint based on temperature rise across fan.
****

a. Heating Mode
(1) When the system is in Heating Mode, space temperature has exceeded its setpoint plus deadband, and the dual temperature coil valve is fully closed the DDC Hardware shall modulate the outside air and relief air dampers toward open and the return air dampers toward closed.

b. Cooling Mode
(2) When the system is in Cooling Mode, Mixed Air Control is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the

outside air, relief, and return air dampers to maintain economizer setpoint (space-temperature setpoint minus [2][ ] degrees F). When this loop is disabled or the Economizer is 'OFF', the outside air and relief air dampers shall be closed.

3.4.16.7 Economizer Enable

The economizer shall be 'ON' when the outside air dry bulb temperature is between the high and low setpoints as shown.

3.4.16.8 Minimum Outside Air Control

When this loop is enabled the DDC Hardware shall open the minimum outside air damper. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.16.9 Fan Proof and Safeties

Supply fan operation shall be subject to fan proof and safeties as shown. Fan proof and system safeties shall be monitored by DDC hardware. Safeties shall be hardware interlocked to fan starter.

Supply fan status (proof) (SF-S)
[Return fan status (proof) (RF-S)]
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proof and safeties shall require a manual reset.]

3.4.16.10 Alarms

The DDC Hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.17 Single Zone with Humidity Control

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proof does not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs

on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.
****

3.4.17.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to Fan enable and safeties.

3.4.17.2 Occupancy Mode:

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.17.3 Fan and System Enable

All Modes: Fan Enable and all DDC Hardware control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fan being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply fan shall be commanded to run. The Minimum Outside Air Control, Space Humidity Control, Preheat Control and Space Temperature Control loops shall be enabled.

[Warm Up / Cool Down: The supply fan shall be commanded to run. The Outside Air Flow Control loop shall be disabled. All other control loops shall be enabled.]

Unoccupied mode: The supply fan and Space Temperature control loop shall be cycled between Enabled and Disabled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. The Outside Air Control and Cooling Coil Control shall be Disabled. All other control loops shall be enabled when the supply fan is enabled and disabled when the supply fan is disabled.

3.4.17.4 Pump Control Loop

When the fan is on the pump shall be on. When the fan is off the pump shall be off.

3.4.17.5 Preheat Coil Control Loop

When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat-coil discharge temperature setpoint as shown as measured by a sensor located as shown. When this loop is disabled, the preheat coil valve shall be closed.

3.4.17.6 Heat Exchanger Control Loop

When the pump is on this loop is enabled and the DDC Hardware shall modulate the heat exchanger valve to maintain the supply water temperature setpoint as shown as measured by a sensor located as shown. When this loop is disabled, the heat exchanger valve shall be closed.

3.4.17.7 Cooling Coil Valve Control Loop

When this loop is enabled the DDC Hardware shall modulate the cooling coil valve to maintain either the supply air temperature setpoint or space humidity setpoint, whichever calls for more chilled water flow, as shown as measured by sensors located as shown. When this loop is disabled, the cooling coil valve shall be closed.

3.4.17.8 Re-Heat Coil Valve Control Loop

The DDC Hardware shall modulate the reheat coil valve to maintain the space temperature setpoint as shown as measured by a sensor located as shown.

3.4.17.9 Humidifier Valve Control Loop

When this loop is enabled the DDC Hardware shall modulate the humidifier valve to maintain the space humidity setpoint as shown as measured by a sensor located as shown. When this loop is disabled, the humidifier coil valve shall be closed.

3.4.17.10 Outside Air Flow Control Loop

When this loop is enabled, the DDC controller shall open the normally closed 2-position outside air damper. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.17.11 Filter

The DDC Hardware shall monitor a differential pressure switch across the filter. The DDC Hardware shall initiate an alarm when the pressure drop across the filter reaches the setpoint.

3.4.17.12 Fan Proof and Safeties

Supply fan operation shall be subject to fan proof and safeties as shown. Fan proof and system safeties shall be monitored by DDC hardware. Safeties shall be hardware interlocked to fan starter.

Supply fan status (proof) (SF-S)
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proof and safeties shall require manual reset.]

3.4.17.13 Alarms

The DDC Hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.18 Single Zone with Hydronic Heating and [DX][Hydronic] Cooling Coils [With][Without] Return Fan

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proof does not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

Designer edit as needed for system with/without return fans.

****

3.4.18.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in Hand, supply fan shall run subject to safeties. When H-O-A switch is in Off, supply fan shall be off. When H-O-A switch is in Auto, supply fan shall run subject to Fan Enable signal and safeties.

[Return fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, return fan shall run subject to safeties. When H-O-A switch is in OFF, return fan shall be off. When H-O-A switch is in AUTO, return fan shall run subject to fan enable signal and safeties.]

3.4.18.2 Occupancy Mode:

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.18.3 Fan and System Enable

All Modes: Fan[s] and all Control Loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fan being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply [and return] fan shall be commanded to run. The Minimum Outside Air Flow Control, Setpoint Reset Control, Mixed Air Temperature Control With Economizer, and Heating/Cooling Coil Control loops shall be enabled.

[Warm Up / Cool Down: The supply [and return] fan shall be commanded to run. Setpoint Reset Control, Mixed Air Temperature Control With Economizer, and Heating/Cooling Coil Control loops shall be enabled. The Minimum Outside Air Flow Control loop shall be disabled.]

Unoccupied mode: The supply [and return] fan shall be cycled (with a deadband) by the DDC Hardware to maintain the building-temperature (night stat) setpoint as shown. The Heating/Cooling Coil Control shall be enabled. All other loops shall be disabled.

3.4.18.4 Setpoint Reset Control Loop

****
NOTE: Choose default supply air setpoint to provide heating during night stat operation.
****

When this loop is enabled the DDC Hardware shall reset the supply air setpoint using a linear reset schedule as shown based on the difference between zone temperature measured by sensor (as shown) and [user adjustable zone setpoint][zone setpoint as shown]. When this loop is disabled, the supply air setpoint shall be as shown.

3.4.18.5 Heating/Cooling Coil Control Loop

****
NOTE: Designer edit for DX or chilled water cooling coil
****

When this loop is enabled the DDC shall [start the DX unit. The DDC shall] modulate the heating coil valve and [stage the DX unit cooling coil valves][the cooling coil valve] to maintain supply air temperature as measured by temperature sensor (as shown) at setpoint as determined by Setpoint Reset Control. There shall be a deadband when temperature is at setpoint between operation of the heating coil valve and the [first stage of DX cooling][cooling coil valve].

3.4.18.6 Mixed Air Temperature Control Loop With Economizer

****

NOTE: Designer should choose difference between supply air setpoint and mixed air setpoint based on temperature rise across fan.

****

When this loop is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the economizer outside air, relief, and return air dampers to maintain the mixed air temperature at a setpoint equal to the supply air setpoint minus [2][ ] degrees F. When this loop is disabled or the Economizer is 'OFF', the economizer outside air and relief air dampers shall be closed.

3.4.18.7 Economizer Enable

The economizer shall be 'ON' when the outside air dry bulb temperature is between the high and low setpoints as shown.

3.4.18.8 Minimum Outside Air Flow Control Loop

When this loop is enabled the DDC Hardware shall modulate the minimum outside air damper to maintain the minimum OA volumetric flow setpoint as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.18.9 Fan Proof and Safeties

Supply [and return] fan operation shall be subject to fan proof and safeties as shown. Fan proof and system safeties shall be monitored by DDC hardware. Safeties shall be hardware interlocked to fan starter.

Supply fan status (proof) (SF-S)
[Return fan status (proof) (RF-S)]
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proof and safeties shall require a reset via [local binary push-button input to the DDC] [local binary push-button input to the DDC or via remote command to the DDC Controller from the OWS] [via remote command to the DDC Controller from the OWS].]

[Fan proof shall require a reset via [local binary push-button input to the DDC] [local binary push-button input to the DDC or via remote command to the DDC Controller from the OWS] [via remote command to the DDC Controller from the OWS].]

3.4.18.10 Alarms

The DDC controller shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.19 Single Zone with Hydronic Heating and Cooling Coil With Return Air Bypass

****

NOTE: The hardware (product) specification requires that the mixed air temperature low limit (freezestat) device include a manual reset at the device. The smoke detectors also require manual reset. In the event of shutdown due to smoke or freeze protection, the system will remain shutdown until the device is reset. The fan proof does not have manual reset. The designer needs to decide if in the event of shutdown due to fan proof should the system remain shutdown until a manual reset button (binary input) is pressed at the DDC controller. Reset could also be performed from an OWS, or the reset requirement can be deleted altogether. It is recommended that you coordinate the decision with the local O&M staff. In the event you choose the OWS option, make sure you show the necessary SNVTs on the Points Schedule.

NOTE: Smoke control is not addressed in this guide specification. Smoke control sequence of operation for each fan system, if beyond the requirements described, will be developed by the designer, based on the requirements and parameters of the project. The designer will account for operation of dampers and fans for pressurization and manual override of interlocks to the fire alarm system. All automatic overrides of normal HVAC control sequences will be activated through the fire protection and smoke control interface panel that the designer will design for the project.

****

3.4.19.1 HAND-OFF-AUTO switches

Supply fan starter shall incorporate integral H-O-A switch. When H-O-A switch is in HAND, supply fan shall run subject to safeties. When H-O-A switch is in OFF, supply fan shall be off. When H-O-A switch is in AUTO, supply fan shall run subject to Fan Enable and safeties.

3.4.19.2 Occupancy Mode:

System shall obtain occupancy from System Scheduler as shown. System shall operate in one of the following modes: OCCUPIED, UNOCCUPIED[, or WarmUp/CoolDown].

3.4.19.3 Fan and System Enable

All Modes: Fan and all control loops shall be subject to proofs and safeties. Failure of proof or safeties shall result in all control loops being disabled, the fan being commanded off, and an alarm condition sent to the OWS.

Occupied mode: The supply fan shall be commanded to run. All Control Loops shall be enabled unless disabled by the individual Control Loop Sequence.

[Warm Up / Cool Down: The supply fan shall be commanded to run. The Economizer Control Loop shall be disabled. All other loops shall be enabled.]

Unoccupied mode: The supply fan shall be cycled (with a deadband) by the DDC controller to maintain the building-temperature (night stat) setpoint as shown. The Economizer Control Loop shall be disabled. All other loops shall be enabled.

3.4.19.4 Heating Coil Control Loop

This loop shall be disabled when the system is in Cooling mode. When this loop is enabled the DDC Hardware shall modulate the heating coil valve to maintain space air temperature as measured by the space temperature sensor (as shown) at setpoint.

3.4.19.5 Chilled Water Control Loop

The cooling coil shall have full flow at all times during Cooling Season.

3.4.19.6 Mixed Air Temperature Control Loop With Economizer

****
NOTE: Designer should choose difference between supply air setpoint and mixed air setpoint based on temperature rise across fan.
****

When this loop is enabled and the Economizer is 'ON' (as determined by the Economizer Enable logic) the DDC Hardware shall modulate the economizer outside air and return air dampers to maintain the space air temperature at setpoint. When this loop is disabled or the Economizer is 'OFF', the outside air dampers shall be closed and the return air dampers shall be open.

3.4.19.7 Economizer Enable

The economizer shall be enabled when the outside air dry bulb temperature is between the high and low setpoints as shown. The economizer shall otherwise be disabled and the outside air damper set at the minimum outside air position and the return air damper opened.

3.4.19.8 Bypass And Supply Damper Control

This loop shall be disabled when the system is in the Heating mode. This loop shall be enabled when the chilled water pump is on, chilled water is available, the fan is on, and the system is in Cooling mode. When enabled this control loop shall modulate the bypass dampers and supply air dampers with Proportional Integral Control to maintain space temperature at space temperature setpoint as shown. When disabled the bypass dampers shall be closed and supply air dampers opened.

3.4.19.9 Filter

The DDC Hardware shall monitor a differential pressure switch across the filter. The DDC Hardware shall initiate an alarm when the pressure drop across the filter reaches the setpoint.

3.4.19.10 Fan Proof and Safeties

Supply fan operation shall be subject to fan proof and safeties as shown. Fan proof and system safeties shall be monitored by DDC Hardware. Safeties shall be hardware interlocked to fan starter.

Supply fan status (proof) (SF-S)
Mixed air temperature low limit (freeze stat) (MA-T-LL)
Supply air smoke (SA-SMK)
Return air smoke (RA-SMK)

[Fan proof and safeties shall require a manual reset.]

3.4.19.11 Alarms

The DDC Hardware shall monitor the safeties, [filter switches], and other alarm points as shown in the Points Schedule and shall generate an alarm based on the conditions shown in the Points Schedule.

3.4.20 VAV Box Terminal Unit Sequences

****
NOTE:
****

****
Note: Show the occ/unocc time schedule for all VAV boxes on the Points Schedule. To minimize complexity, it is recommended that you use the same schedule for all boxes served by a common air handler.

Note: If zone temperature setpoint is not occupant adjustable from the zone thermostat, edit the sequence and show the setpoint in the Points Schedule.

Note: The occupancy sensor specification requires a 15 minute off-mode delay prior to entering the unoccupied mode. If a different time is desired, show it in the thermostat schedule.

Note: Shutdown of the primary air handler fan is accomplished using a smoke detector contact hardwired directly to the supply fan. A LonWorks Emergency mode shutdown SNVT (input to each AHU and VAV controller) is also available, but is not specified here and its use should be coordinated with other

applicable specifications, local requirements, and codes.
****

3.4.20.1 Cooling-Only VAV Box

Occupancy Mode. The VAV box DDC Hardware shall obtain its occupancy mode from the System Scheduler as shown [and from Occupancy sensor as shown]:

a. -Occupied Mode: Upon receipt of an occupied command from the System Scheduler [or local occupancy sensor] the VAV box shall operate at the occupied zone temperature setpoint [via the occupant adjustable thermostat] as shown.

b. -Unoccupied Mode: Upon receipt of an unoccupied command from the System Scheduler [and local occupancy sensor] the VAV box shall operate at the configured unoccupied zone temperature setpoint as shown.

All Modes. The DDC Hardware shall modulate the VAV box damper to maintain box airflow at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Upon a rise in space temperature above setpoint and subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone setpoint and zone temperature as shown.

3.4.20.2 VAV Box with Reheat

Occupancy Mode. The VAV box DDC Hardware shall obtain its occupancy mode from the System Scheduler as shown [and from Occupancy sensor as shown]:

a. -Occupied Mode: Upon receipt of an occupied command from the System Scheduler [or local occupancy sensor] the VAV box shall operate at the occupied zone temperature setpoint [via the occupant adjustable thermostat] as shown.

-Unoccupied Mode: Upon receipt of an unoccupied command from the system scheduler [and local occupancy sensor] the VAV box shall operate at the configured unoccupied zone temperature setpoint as shown.

All Modes. The DDC Hardware shall modulate the VAV box damper to maintain box airflow at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Space temperature control sequencing shall be as shown. Upon a rise in space temperature above setpoint, subject to the deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone setpoint and zone temperature. Upon a fall in space temperature below setpoint, subject to the deadband as shown, the airflow shall be maintained at a fixed air flow setpoint (with a setting independent of the cooling minimum air flow), and the heating valve shall modulate towards open or the staged electric resistance heating coil(s) shall cycle on in sequence. VAV boxes with electric resistance heating elements shall use a proof of flow safety switch to deactivate the heating elements in the absence of sufficient flow in accordance with the VAV box manufacturer specifications.

3.4.20.3 Series Fan Powered VAV Box

****

NOTE: Note: Fans located in series fan-powered VAV boxes must start prior to the AHU fan that serves these boxes. Coordinate this requirement with the

VAV AHU control sequence.
****

Series fan-powered VAV box fans shall start prior to starting the AHU fan that serves the VAV boxes.

Occupancy Mode. The VAV box DDC Hardware shall obtain its occupancy mode from the system scheduler as shown [and from Occupancy sensor as shown]:

a. -Occupied Mode: Upon receipt of an occupied command from the System Scheduler [or local occupancy sensor] the VAV box shall operate at the occupied zone temperature setpoint [via the occupant adjustable thermostat] as shown.

b. -Unoccupied Mode: Upon receipt of an unoccupied command from the system scheduler [and local occupancy sensor] the VAV box shall operate at the configured unoccupied zone temperature setpoint as shown.

All Modes. The DDC Hardware shall modulate the VAV box damper to maintain box inlet airflow at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Space temperature control sequencing shall be as shown. Upon a rise in space temperature above setpoint, subject to the deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone setpoint and zone temperature. Upon a fall in space temperature below setpoint, subject to the deadband as shown, the airflow at the VAV box inlet shall be maintained at a fixed air flow setpoint (with a setting independent of the cooling minimum air flow) and [the heating valve shall modulate towards open.] [the staged electric resistance heating coil(s) shall cycle on in sequence. VAV boxes with electric resistance heating elements shall use a proof of flow safety switch to deactivate the heating elements in the absence of sufficient flow in accordance with the VAV box manufacturer specifications.]

3.4.20.4 Parallel Fan Powered VAV Box

Occupancy Mode. The VAV box DDC Hardware shall obtain its occupancy mode from the System Scheduler as shown [and from Occupancy sensor as shown]:

a. -Occupied Mode: Upon receipt of an occupied command from the system scheduler [or local occupancy sensor] the VAV box shall operate at the occupied zone temperature setpoint [via the occupant adjustable thermostat] as shown.

b. -Unoccupied Mode: Upon receipt of an unoccupied command from the system scheduler [and local occupancy sensor] the VAV box shall operate at the configured unoccupied zone temperature setpoint as shown.

All Modes. The DDC Hardware shall modulate the VAV box damper to maintain box airflow at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Space temperature control sequencing shall be as shown. Upon a rise in space temperature above setpoint, subject to the deadband as shown, the parallel fan shall be off, and the airflow setpoint shall be adjusted between minimum and maximum flow based on the difference between zone setpoint and zone temperature. Upon a fall in space temperature below setpoint, subject to the deadband as shown, the airflow at the VAV box inlet shall be maintained at a fixed air flow setpoint (with a setting independent of the cooling minimum air flow) and the fan shall cycle on to mix supply air with recirculated room/plenum air. Upon a continued fall in space temperature, the parallel fan shall remain on, and [the heating valve shall modulate towards open.] [the staged electric resistance heating coil(s) shall cycle on in sequence. VAV boxes with electric resistance heating elements shall use a proof of flow safety switch to deactivate the heating elements in the absence of sufficient flow in accordance with the VAV box manufacturer specifications.]

3.4.21 Secondary Hydronic with Variable Speed Pumping

****

NOTE: This system assumes a manual start of system via a Season Mode (Heating/Cooling) SNVT. Design option is shown below to permit automatic start of system via request for heating or cooling from terminal loads. Designer should select hot water or chilled water sequences based on the application. Designer shall select On/Off pump control or use of a VFD.

****

[3.4.21.1 Secondary Hot Water Pump On/Off Control:

SHWP control shall have a "HAND-OFF-AUTO" switch controlling the pump. When the switch is in "AUTO", the SHWP shall run if the OA-T is below a configurable setpoint (with a deadband) and the Season Mode is Heating. SHWP shall run with the H-O-A switch in "HAND." SHWP shall have proofs.]

Season Mode shall be obtained from [terminal loads][Season Mode (Heating/Cooling) switch].

[3.4.21.2 Secondary Hot Water Pump Variable Speed Pumping Control:

SHWP control shall have a "HAND-OFF-AUTO" switch controlling the pump. When the switch is in AUTO, the OA-T is below a configurable setpoint (with a deadband), and the Season Mode is Heating then the SHWP shall run. Otherwise the SHWP shall be off. If the SHWP is running, the SHWP speed shall be modulated to maintain SHWP-P (from differential pressure sensor located as shown) at a configurable setpoint.
When the switch is in "HAND":
    SHWP shall run. SHWP speed shall be controlled via manual input located at the SHWP VFD. (This manual speed input shall be interlocked with "HAND-OFF-AUTO" switch.)
When the switch is in "OFF":
    SHWP shall be Off. SWHP speed control loop shall be disabled.
    SHWP shall have proofs.]

[3.4.21.3 Secondary Chilled Water Pump On/Off Control:

SCWP control shall have a "HAND-OFF-AUTO" switch controlling the pump. When the switch is in "AUTO", the SCWP shall run if the Season Mode is Cooling and the occupied mode according to the System Scheduler as shown is "Occupied". SCWP shall run with the H-O-A switch in "HAND." SCWP shall have proofs.]

[3.4.21.4 Secondary Chilled Water Pump Variable Speed Pumping Control:

SCWP control shall have a "HAND-OFF-AUTO" switch controlling the pump.
When the switch is in "AUTO":
SCWP shall run when the Season Mode is Cooling and the occupied mode according to the system scheduler as shown is "Occupied".
If the SHWP is running, the SHWP speed shall be modulated to maintain SHWP-P (from differential pressure sensor located as shown) at a configurable setpoint.
When the switch is in "HAND":
SCWP shall run. SCWP speed shall be controlled via manual input located at the SCWP VFD. (This manual speed input shall be interlocked with "HAND-OFF-AUTO" switch.)
When the switch is in "OFF":
SCWP shall be Off. SCHP speed control loop shall be disabled.
SCWP shall have proofs.]

3.5 CONTROLLER TUNING

The Contractor shall tune each controller in a manner consistent with that described in the ASHRAE Hdbk. Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. Each loop shall be tuned while the system or plant is operating at a high gain (worst case) condition, where high gain can generally be defined as a low-flow or low-load condition. Upon final adjustment of the PID settings, in response to a change in controller setpoint, the controlled variable shall settle out at the new setpoint with no more than two (2) oscillations above and below setpoint. Upon settling out at the new setpoint the controller output shall be steady. With the exception of naturally slow processes such as zone temperature control, the controller shall settle out at the new setpoint within five (5) minutes. The contractor shall return the controller to its original setpoint and shall record and submit the final PID configuration settings with the O&M manual and on the associated Points Schedule.

3.6 START-UP AND START-UP TEST

The Contractor shall perform the following startup tests for each control system to ensure that the described control system components are installed and functioning per this specification.

a. General: The Contractor shall adjust, calibrate, measure, program, configure, set the time schedules, set alarms, and otherwise perform all necessary actions to ensure that the systems function as described in the sequence of operation and other contract documents.

b. Systems Check: An item-by-item check shall be performed for each HVAC system;

(1) Step 1 - System Inspection: With the system shut down, it shall be verified that power and main air are available where required and that all output devices are in their failsafe and normal positions. Each local display panel and, where applicable, each OWS shall be inspected to verify that all displays indicate shutdown conditions.

(2) Step 2 - Calibration Accuracy Check: With the system shut down, an accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by

comparing each local display panel and, where applicable, each OWS readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement array location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute of Standards And Technology standards.

(3) Step 3 - Calibration Accuracy Check: With the system running, the calibration accuracy check procedure from step 2 shall be repeated. The step 2 and 3 calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two operating points (shutdown and running) are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the two-point calibration accuracy check repeated.

(4) Step 4 - Actuator Range Check: With the system running, a signal shall be applied to each actuator through the DDC Hardware controller. Proper operation of the actuators and positioners for all actuated devices shall be verified and the signal levels shall be recorded for the extreme positions of each device. The signal shall be varied from live zero to full range, and it shall be verified that the actuators travel from zero stroke to full stroke within the signal range. Where applicable, it shall be verified that all sequenced actuators move from zero stroke to full stroke in the proper direction, and move the connected device in the proper direction from one extreme position to the other.

c. Weather Dependent Test: Weather dependent test procedures that cannot be performed by simulation shall be performed in the appropriate climatic season. When simulation is used, the actual results shall be verified in the appropriate season.

d. Two-Point Accuracy Check: A two-point accuracy check of the calibration of each HVAC control system sensing element and transmitter shall be performed by comparing the DDC system readout to the actual value of the variable measured at the sensing element and transmitter or airflow measurement station location. Digital indicating test instruments shall be used, such as digital thermometers, motor-driven psychrometers, and tachometers. The test instruments shall be at least twice as accurate as the specified sensing element-to-DDC system readout accuracy. The calibration of the test instruments shall be traceable to National Institute Of Standards And Technology standards. The first check point shall be with the HVAC system in the shutdown condition, and the second check point shall be with the HVAC system in an operational condition. Calibration checks shall verify that the sensing element-to-DDC system readout accuracies at two points are within the specified product accuracy tolerances. If not, the device shall be recalibrated or replaced and the calibration check repeated.

Test Report: Upon completion of the Start-Up Test, the contractor shall prepare and submit a Start-Up and Testing Report documenting the results of the tests performed and certifying that the system is installed and functioning per this specification, and is ready for the Performance

Verification Test (PVT).

3.7 PERFORMANCE VERIFICATION TEST (PVT)

****
NOTE: A set of Field Test Procedures are being developed by an A/E under contract with Huntsville Center. Once complete, these Test Procedures will be included or referenced here.

Brief interim guidance is provided here.
****

3.7.1 PVT Procedures

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NOTE: The designer must decide whether to require one-point accuracy checks and/or inlet and outlet air temperature measurements.

Project specific requirements should be added, particularly for problematic controls based on designer and user experience.
****

The performance verification test procedures shall explain, step-by-step, the actions and expected results that will demonstrate that the control system performs in accordance with the sequences of operation, and other contract documents. [The PVT shall include a one-point accuracy check of each sensor.][The PVT shall include inlet and outlet air temperature measurements for all terminal units.]The PVT procedure shall describe a methodology to measure and trend the Network Bandwidth Usage on the backbone and compare it to the Bandwidth Usage Calculation submittal. A control system performance verification test equipment list shall be included that lists the equipment to be used during performance verification testing. The list shall include manufacturer name, model number, equipment function, the date of the latest calibration, and the results of the latest calibration.

3.7.2 PVT Execution

The Contractor shall demonstrate compliance of the control system with the contract documents. Using test plans and procedures previously approved by the Government, the Contractor shall demonstrate all physical and functional requirements of the project. The performance verification test shall show, step-by-step, the actions and results demonstrating that the control systems perform in accordance with the sequences of operation. The performance verification test shall measure and trend the Network Bandwidth Usage and compare it to the Bandwidth Usage Calculation submittal. The performance verification test shall not be started until after receipt by the Contractor of written permission by the Government, based on Government approval of the Start-Up and Testing Report and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems.

3.7.3 PVT Report

Contractor shall prepare a PVT report documenting all tests performed during the PVT and their results. The PVT report shall include all tests in the PVT Procedures and any other testing performed during the PVT. Failures and repairs shall be documented with test results.

3.8 TRAINING

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NOTE: Training requirements should be coordinated with the user (including the Controls/HVAC/Electrical shop supervisor). Extent of training should be based on the needs of the installation personnel.
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A training course shall be conducted for [___] operating staff members designated by the Government in the maintenance and operation of the system, including specified hardware and software. The training period, for a total of [32][___] hours of normal working time, shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site. Audiovisual equipment and [___] sets of all other training materials and supplies shall be provided. A training day is defined as 8 hours of classroom instruction, including two 15 minute breaks and excluding lunchtime, Monday through Friday, during the daytime shift in effect at the training facility.

3.8.1 Training Documentation

The contractor shall prepare training documentation consisting of:

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NOTE: Designer must choose appropriate shop supervisor(s) to coordinate training attendance.
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a. course attendance list: A List of course attendees which shall be developed in coordination with and signed by the [Controls][HVAC][Electrical] shop supervisor.

b. Training Manuals: Training manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. Where the Contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Government as a part of the printed training manuals. Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site.

3.8.2 Training Course Content

For guidance in planning the required instruction, the Contractor shall assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. The training course shall cover all of the material contained in the Operating and Maintenance Instructions, the layout and location of each controller enclosure, the layout of one of each type of unitary equipment and the locations of each, the location of each control device external to the panels, the location of the compressed air station, preventive maintenance, troubleshooting, diagnostics, calibration, adjustment, commissioning, tuning, repair procedures, and use of the GPPC Programming software. Typical systems and similar systems may be treated as a group, with instruction on the physical layout of one such system. The results of the performance verification test and the Start-up and Testing Report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

-- End of Section --