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USACE / NAVFAC / AFCEC / NASA **UFGS-23 09 23 (May 2011)**
Change 1 - 02/14

Preparing Activity: USACE **Superseding**
UFGS-23 09 23 (May 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2014

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SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 09 23

LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS

05/11

-- End of Section Table of Contents --

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SECTION 23 09 23

LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS
05/11

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NOTE: This guide specification covers the requirements for direct digital control for HVAC and other building control systems based on LonWorks open system technologies including the CEA-709.1-D protocol.

Adhere to UFC 1-300-02 **Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.**

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR)**.**
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PART 1 GENERAL

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NOTE: This section is for use on all USACE and AFCEC projects and for additions or retrofits to existing NAVFAC LonWorks systems. New NAVFAC systems should use Section 23 09 23.13 20 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

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 25 10 10 LONWORKS UTILITY MONITORING AND

CONTROL SYSTEM (UMCS). For projects that require the building system to provide UMCS functionality (without connection to a UMCS), the designer must include the necessary requirements from Section 25 10 10. 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 must be in accordance with UFC 3-410-02 LonWorks Direct Digital Control for HVAC and Other Local Building Systems. 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 and in this section, 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 ERDC-CERL Building Automation Systems (BAS) Website **located at: https://eko.usace.army.mil/public/fa/bas**

Template drawings in electronic format for use with this section are available in online at: http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf

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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print 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 INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating
AMCA 511	(2013) Certified Ratings Program for Air Control Devices

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

ASHRAE FUN IP	(2013) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2013) Fundamentals Handbook, SI Edition

ASME INTERNATIONAL (ASME)

ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A269	(2013) Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A536	(1984; R 2009) Standard Specification for Ductile Iron Castings
ASTM B88	(2009) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2013) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D1693	(2013) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D635	(2010) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position

CONSUMER ELECTRONICS ASSOCIATION (CEA)

CEA-709.1-D	(2014) Control Network Protocol Specification
CEA-709.3	(1999; R 2004) Free-Topology Twisted-Pair Channel Specification
CEA-852-C	(2014) Tunneling Component Network Protocols Over Internet Protocol Channels

FLUID CONTROLS INSTITUTE (FCI)

FCI 70-2	(2013) Control Valve Seat Leakage

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

ISA - INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

LONMARK INTERNATIONAL (LonMark)

LonMark Interoperability Guide	(2005) LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4
LonMark SCPT List	(2003) LonMark SCPT Master List; Version 12
LonMark SNVT List	(2003) LonMark SNVT Master List; Version 113
LonMark XIF Guide	(2001) LonMark External Interface File Reference Guide; Revision 4.402

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.1	(2008) Electric Meters Code for Electricity Metering
ANSI C12.20	(2010) Electricity Meters - 0.2 and 0.5 Accuracy Classes
NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA/ANSI C12.10	(2011) Physical Aspects of Watthour Meters - Safety Standards

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

THE INTERNET ENGINEERING TASK FORCE (IETF)

IETF RFC 4361	(2006) Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 5085-3	(2006; Reprint Nov 20121) Low Voltage Transformers - Part 3: Class 2 and Class 3 Transformers
UL 555	(2006; Reprint May 2014) Standard for Fire Dampers
UL 555S	(2014) Smoke Dampers
UL 916	(2007; Reprint Dec 2013) Standard for Energy Management Equipment
UL 94	(2013) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in the Section but are included here for completeness.

a. Application Generic Controller (AGC): A device that is furnished with a (limited) pre-established application that also has the capability of being programmed. Further, the ProgramID and XIF file of the device are fixed. The programming capability of an AGC may be less flexible than that of a General Purpose Programmable Controller (GPPC).

b. Application Specific Controller (ASC): A device that is furnished with a pre-established built in application that is configurable but not re-programmable. An ASC has a fixed factory-installed application program (i.e Program ID) with configurable settings.

c. Binary: A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. 'Digital' is sometimes used interchangeably with 'binary'.

d. Binding: The act of establishing communications between CEA-709.1-D devices by associating the output of a device to the input of another so that information is automatically (and regularly) sent.

e. Building Control Network (BCN): The CEA-709.1-D control network consisting of one or more TP/FT-10 channels, and possibly a single TP/XF-1250 channel, in doubly terminated bus topology.

f. Building Point of Connection (BPOC): The BPOC is the point of connection between the UMCS network backbone (an IP network) and the building control network backbone. The hardware at this location, that provides the connection is referred to as the BPOC Hardware. In general, the term "BPOC Location" means the place where this connection occurs, and "BPOC Hardware" means the device that provides the connection. Sometimes the term "BPOC" is used to mean either and its actual meaning (i.e. location or hardware) is determined by the context in which it is used.

g. Channel: A portion of the control network consisting of one or more segments connected by repeaters. Channels are separated by routers. The device quantity limitation is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 128 devices per channel.

h. Commandable: See Overridable.

i. Configuration Property: Controller parameter used by the application which is usually set during installation/testing and seldom changed. For example, the P and I settings of a P-I control loop. Also see 'Standard Configuration Property Type (SCPT)'

j. Control Logic Diagram: A graphical representation of control logic for multiple processes that make up a system.

k. Domain: A grouping of up to 32,385 nodes that can communicate directly with each other. (Devices in different domains cannot communicate directly with each other.) See also Node Address.

l. Explicit Messaging: A non-standard and often vendor (application) specific method of communication between devices where each message contains a message code that identifies the type of message and the devices use these codes to determine the action to take when the message is received.

m. External Interface File (XIF): A file which documents a device's external interface, specifically the number and types of LonMark objects, the number, types, directions, and connection attributes of network variables, and the number of message tags.

n. Functional Profile: A standard description, defined by LonMark, of one or more LonMark Objects used to classify and certify devices.

o. Gateway: A device that translates from one protocol application data format to another. Devices that change only the transport mechanism of the protocol - "translating" from TP/FT-10 to Ethernet/IP for example - are not gateways as the underlying data format does not change. Gateways are also called Communications Bridges or Protocol Translators.

p. General Purpose Programmable Controller (GPPC): Unlike an ASC or AGC, a GPPC is not furnished with a fixed application program and does not have a fixed ProgramID or XIF file. A GPPC can be (re-)programmed, usually using vendor-supplied software. When a change to the program affects the external interface (and the XIF file) the ProgramID will change..

q. LonMark Object: A collection of network variables, configuration properties, and associated behavior defined by LonMark International and described by a Functional Profile. It defines how information is exchanged between devices on a network (inputs from and outputs to the network).

r. LNS Plug-in: Software which runs in an LNS compatible software tool, typically a network configuration tool. Device configuration plug-ins provide a 'user friendly' method to edit a device's configuration properties.

s. LonMark: See LonMark International. Also, a certification issued by LonMark International to CEA-709.1-D devices.

t. LonMark International: Standards committee consisting of numerous independent product developers, system integrators and end users dedicated to determining and maintaining the interoperability guidelines for LonWorks. Maintains guidelines for the interoperability of CEA-709.1-D devices and issues the LonMark Certification for CEA-709.1-D devices.

u. LonMark Interoperability Association: See 'LonMark International'.

v. LonWorks: The term used to refer to the overall technology related to the CEA-709.1-D protocol (sometimes called "LonTalk"), (including the protocol itself, network management, interoperability guidelines and products.

w. LonWorks Network Services (LNS): A network management and database standard for CEA-709.1-D devices.

x. Monitoring and Control (M&C) Software: The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

y. Network Variable: See 'Standard Network Variable Type (SNVT)'.

z. Network Configuration Tool: The software used to configure the control network and set device configuration properties. This software creates and modifies the control network database (LNS Database).

aa. Node: A device that communicates using the CEA-709.1-D protocol and is connected to a CEA-709.1-D network.

bb. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number and Node number. Note that the "Node number" portion of the address is the number assigned to the device during installation and is unique within a subnet. This is not the factory-set unique Node ID (see Node ID).

cc. Node ID: A unique 48-bit identifier assigned (at the factory) to each CEA-709.1-D device. Sometimes called the Neuron ID.

dd. Overridable: A point is overridable if its value can be changed using network variables outside of the normal sequence of operations where this change has priority over the sequence. Typically this override is from the Utility Monitoring and Control System (UMCS) Monitoring and Control (M&C) Software. Note that that this definition is not standard throughout industry; some refer to this capability as "commandable" and some use this term to refer to changing a value from a configuration tool.

ee. Polling: A device requesting data from another device.

ff. Program ID: An identifier (number) stored in the device (usually EEPROM) that identifies the node manufacturer, functionality of device (application & sequence), transceiver used, and the intended device usage.

gg. Repeater: A device that connects two control network segments and retransmits all information received on one side onto the other.

hh. Router: A device that connects two channels and controls traffic between the channels by retransmitting signals received from one subnet onto the other based on the signal destination. Routers are used to subdivide a control network and to control bandwidth usage.

ii. Segment: A 'single' section of a control network that contains no repeaters or routers. There is generally a limit on the number of devices on a segment, and this limit is dependent on the topology/media and device type. For example, a TP/FT-10 network with locally powered devices is limited to 64 devices per segment.

jj. Service Pin: A hardware push-button on a device which causes the device to broadcast a message (over the control network) containing its Node ID and Program ID. This broadcast can also be initiated via software.

kk. Standard Configuration Property Type (SCPT): Pronounced 'skip-it'. A standard format type (maintained by LonMark International) for Configuration Properties.

ll. Standard Network Variable Type (SNVT): Pronounced 'snivet'. A standard format type (maintained by LonMark International) used to define data information transmitted and received by the individual nodes. The term SNVT is used in two ways. Technically it is the acronym for Standard Network Variable Type, and is sometimes used in this manner. However, it is often used to indicate the network variable itself (i.e. it can mean "a network variable of a standard network variable type"). In general, the intended meaning should be clear from the context.

mm. Subnet: Consists of a logical grouping of up to 127 nodes, where the logical grouping is defined by node addressing. Each subnet is assigned a number which is unique within the Domain. See also Node Address.

nn. TP/FT-10: A Free Topology Twisted Pair network defined by CEA-709.3. This is the most common media type for a CEA-709.1-D control network.

oo. TP/XF-1250: A high speed (1.25 Mbps) twisted pair, doubly-terminated bus network defined by the LonMark Interoperability Guidelines. This media is typically used only as a backbone media to connect multiple TP/FT-10 networks.

pp. UMCS Network: An IP network connecting multiple building control networks (BCNs) to the Monitoring and Control Software using the CEA-852-C standard.

qq. User-defined Configuration Property Type (UCPT): Pronounced 'u-keep-it'. A Configuration Property format type that is defined by the device manufacturer.

rr. User-defined Network Variable Type (UNVT): A network variable format defined by the device manufacturer. Note that UNVTs create non-standard communications (other vendor's devices may not correctly interpret it) and may close the system and therefore are not permitted by this specification.

1.3 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.

1.3.1 System Requirements

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

a. The control system shall be an open implementation of LonWorks technology using CEA-709.1-D as the communications protocol and using LonMark Standard Network Variable Types as defined in LonMark SNVT List exclusively for communication over the network.

b. LonWorks Network Services (LNS) shall be used for all network management including addressing and binding of network variables. Submit to the project site two copies of the complete, fully-commissioned, valid, as-built Final LNS database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Each copy shall be on optical disk 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. The submitted LNS Database shall consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}. All devices shall be on-line and commissioned into the LNS database.

c. The hardware shall perform the control sequences as specified and shown and 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. 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 and as needed to meet the requirements of this specification.

j. All DDC devices installed under this specification shall communicate via CEA-709.1-D. 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.

1.3.2 Verification of Dimensions

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.3.3 Drawings

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

1.3.4 Data Packages/Submittals Requirements

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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 Services implementation 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 with both description and quantity being required.

Coordinate the review of all submittals with the project site. The site may have a System Integrator or other individual/office that should review all submittals before acceptance of the system.

Most of the submittals included in this Section are critical and require Government review. Any added submittals, normally, should be for information only and reviewed through the Contractor Quality Control system.

****

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 the Federal Acquisition Regulation Supplement (FARS) and shall contain no proprietary information and be delivered with unrestricted rights.

1.4 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control

System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES, and TABLE I. PROJECT SEQUENCING:

SD-02 Shop Drawings

DDC Contractor Design Drawings[; G][; G, [_____]]
Draft As-Built Drawings[; G][; G, [_____]]
Final As-Built Drawings[; G][; G, [_____]]

SD-03 Product Data

Manufacturer's Catalog Data[; G][; G, [_____]]
Programming Software[; G][; G, [_____]]
GPPC Application Programs[; G][; G, [_____]]
AGC Application Programs[; G][; G, [_____]]
XIF files[; G][; G, [_____]]
Draft LNS Database[; G][; G, [_____]]
Final LNS Database[; G][; G, [_____]]
LNS Plug-in[; G][; G, [_____]]

SD-06 Test Reports

Existing Conditions Report[; G][; G, [_____]]
Start-Up and Start-Up Testing Report[; G][; G, [_____]]
PVT Procedures[; G][; G, [_____]]
PVT Report[; G][; G, [_____]]
Pre-Construction QC Checklist[; G][; G, [_____]]
Post-Construction QC Checklist[; G][; G, [_____]]

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions[; G][; G, [_____]]
Training Documentation[; G][; G, [_____]]

SD-11 Closeout Submittals

Closeout QC Checklist[; G][; G, [_____]]

1.5 PROJECT SEQUENCING

TABLE I: PROJECT SEQUENCING lists the sequencing 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). TABLE I does not specify overall project milestone and completion dates[; these dates are specified in the contract documents][_____].

a. Sequencing for submittals: The sequencing 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 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Government, revise the submittal and resubmit it to the Government within [14][_____] days of notification that the submittal has been rejected. Upon resubmittal there will be an additional Government review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Government.

b. Sequencing for Activities: The sequencing specified for activities indicates the earliest the activity may begin.

c. Abbreviations: In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

TABLE I. PROJECT SEQUENCING

ITEM #	TYPE	DESCRIPTION	SEQUENCING (START OF ACTIVITY or DEADLINE FOR SUBMITTAL)
1	S	Existing Conditions Report	
2	S	DDC Contractor Design Drawings	
3	S	Manufacturer's Catalog Data	
4	S	Network Bandwidth Usage Calculations	
5	S	Pre-construction QC Checklist	
6	E	Install Building Control System	AAO #1 thru #5
7	E	Start-Up and Start-Up Testing	ACO #6
8	S	Post-Construction QC Checklist	[_____] days ACO #7
9	S	Programming Software	[_____] days ACO #7

TABLE I. PROJECT SEQUENCING			
10	S	XIF Files	[_____] days ACO #7
11	S	LNS Plug-ins	[_____] days ACO #7
12	S	Start-Up and Start-Up Testing Report	[_____] days ACO #7
13	S	Draft As-Built Drawings	[_____] days ACO #7
14	S	Draft LNS Database	[_____] days ACO #7
15	S	PVT Procedures	[_____] days before schedule start of #16 and AAO #12
16	E	PVT	AAO #13, #14 and #15
17	S	PVT Report	[_____] days ACO #16
18	S	GPPC Application Programs and	[_____] days AAO #17
19	S	Final LNS Database	[_____] days AAO #17
20	S	Final As-Built Drawings	[_____] days AAO #17
21	S	O&M Instructions	AAO #20
22	S	Training Documentation	AAO #12 and [_____] days before scheduled start of #23
23	E	Training	AAO #21 and #22
24	S	Closeout QC Checklist	ACO #23

1.6 QUALITY CONTROL (QC) CHECKLISTS

The Contractor's Chief Quality Control (QC) Representative shall complete the QC Checklist in APPENDIX A and submit [4] [_____] copies of the Pre-Construction QC Checklist, [4] [_____] copies of the Post-Construction QC Checklist and [4] [_____] copies of the Closeout QC Checklist. The QC Representative shall verify each item in the Checklist and initial in the provided area to indicate that the requirement has been met. The QC Representative shall sign and date the Checklist prior to submission to the Government.

The QC Checklist in APPENDIX A is available in electronic format for use with this section at: http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf

1.7 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.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit [2] [_____] copies of the Operation and Maintenance Instructions, indexed and in booklet form. The Operation and Maintenance Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package. The HVAC control System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 3" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA for each piece of control equipment.

b. "Manufacturer Data Package 4" as described in Section 01 78 23 OPERATION AND MAINTENANCE DATA for all air compressors.

c. HVAC control system sequences of operation formatted as specified.

d. Procedures for the HVAC system start-up, operation and shut-down including the manufacturer's supplied procedures for each piece of equipment, and procedures for the overall HVAC system.

e. As-built HVAC control system detail drawings formatted as specified.

f. A list of the 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 Start-Up Testing Report.

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

1.9 SURGE PROTECTION

1.9.1 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.

1.9.2 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 protected against the following two waveforms:

a. A waveform with a 10-microsecond rise time, a 1,000-microsecond decay time and a peak current of 60 amps.

b. A waveform with an 8-microsecond rise time, a 20-microsecond decay time and a peak current of 500 amperes.

1.10 INPUT MEASUREMENT ACCURACY

****

NOTE: This paragraph is referenced elsewhere in the specification. If this paragraph is edited, removed, renamed etc make sure to verify that all references to it are updated as needed.

****

Sensors, transmitters and DDC Hardware shall be selected, installed and configured such that the maximum error of the measured value at the SNVT output of the DDC hardware is less than 105 percent of the maximum allowable error specified for the sensor or instrumentation.

PART 2 PRODUCTS

PART 2 of this specification covers requirements for Products (equipment). Installation requirements for these products are covered in PART 3 of this specification.

2.1 EQUIPMENT

2.1.1 General 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.

2.1.2 Operation Environment Requirements

Unless otherwise specified, all products shall be rated for continuous operation under the following conditions:

2.1.2.1 Pressure

Pressure conditions normally encountered in the installed location.

2.1.2.2 Vibration

Vibration conditions normally encountered in the installed location.

2.1.2.3 Temperature

****

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

****

2.1.2.3.1 Products Installed Indoors

Ambient temperatures in the range of 0 to 50 degrees C 32 to 112 degrees F and temperature conditions outside this range normally encountered at the installed location.

2.1.2.3.2 Products Installed Outdoors or in Unconditioned Indoor Spaces

Ambient temperatures in the range of [-37 to +66 degrees C -35 to +151 degrees F] [_____] and temperature conditions outside this range normally encountered at the installed location.

2.1.2.4 Humidity

10 to 95 percent 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: In outdoor applications specify Type 3 unless hosedown of the enclosure is anticipated, in which case specify Type 4.

For retrofit projects in older mechanical rooms or where hosedown of the enclosure is anticipated specify Type 4 enclosures. Type 4 provides a greater degree of protection in dirty and wet environments than does Type 2.

****

Enclosures shall meet the following minimum requirements. Enclosures supplied as an integral (pre-packaged) part of another product are acceptable.

2.2.1.1 Outdoors

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

2.2.1.2 Mechanical and Electrical Rooms

Enclosures located in mechanical or electrical rooms shall meet NEMA 250 [Type 2] [Type 4] requirements.

2.2.1.3 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.

2.2.2 Weathershields

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 conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near outside air intake ducts shall be installed such that normal outside air flow does not cause rainwater to strike the sensor. Weathershields shall be constructed of galvanized steel painted white, unpainted aluminum, aluminum painted white, or white PVC.

2.3 TUBING

2.3.1 Copper

Copper tubing shall conform to ASTM B88 and ASTM B88M

2.3.2 Stainless Steel

Stainless steel tubing shall conform to ASTM A269

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 D635, shall have UL 94 V-2 flammability classification or better, and shall withstand stress cracking when tested in accordance with ASTM D1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

2.4 NETWORK HARDWARE

2.4.1 CEA-709.1-D Network Routers

CEA-709.1-D Routers (including routers configured as repeaters) shall meet the requirements of CEA-709.1-D and shall provide connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel..

2.4.2 Gateways

Gateways shall perform bi-directional protocol translation from one non-CEA-709.1-D protocol to CEA-709.1-D. Gateways shall incorporate a network connection to a TP/FT-10 network in accordance with CEA-709.3 and a connection for a non-CEA-709.1-D network.

2.4.3 CEA-709.1-D to IP Router

CEA-709.1-D to IP Routers shall perform layer 3 routing of CEA-709.1-D packets over an IP network in accordance with CEA-852-C. The router shall provide the appropriate connection to the IP network and connections to the CEA-709.3 TP/FT-10 or TP/XF-1250 network. CEA-709.1-D to IP Routers shall support the Dynamic Host Configuration Protocol (DHCP; IETF RFC 4361 for IP configuration and the use of an CEA-852-C Configuration Server (for CEA-852-C configuration), but shall not rely on these services for configuration. CEA-709.1-D to IP Routers shall be capable of manual configuration via a console RS-232 port.

2.5 WIRE AND CABLE

All wire and cable shall meet the requirements of NFPA 70 and NFPA 90A in addition to the requirements of this specification.

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 Network Wiring

Control network wiring shall be twisted pair in accordance with CEA-709.3.

2.5.3 Control Wiring for Binary Signals

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

2.5.4 Control 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.

2.5.5 Control Wiring for Analog Signals

Control Wiring for Analog Signals shall be 18 AWG, copper, single- or multiple-twisted, minimum 50 mm 2 inch lay of twist, 100 percent 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.

2.5.6 Transformers

Transformers shall be UL 5085-3 approved. Transformers shall be sized so that the connected load is no greater than 80 percent 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 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure. Unless otherwise specified or shown, valve leakage shall meet FCI 70-2 Class IV leakage rating (0.01 percent of valve Kv). Unless otherwise specified or shown, valves shall have globe-style bodies. Unless otherwise specified:

a. bodies for valves smaller than 50 mm 2 inches shall be brass or bronze, with threaded or union ends

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

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

d. bodies for valves larger than 50 mm 2 inches shall be provided with flanged-end connections.

e. for modulating applications, valve Kv (Cv) shall be within 100 to 125 percent 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.

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

2.6.1 Ball Valves

Balls shall be stainless steel or nickel plated brass. Valves shall have blow-out proof stems. In steam and high temperature hot water applications, the valve-to-actuator linkage shall provide a thermal break.

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 or with ductile iron bodies in accordance with ASTM A536. Butterfly valves shall have non-corrosive discs, stainless steel shafts supported by bearings, and EPDM seats suitable for temperatures from -29 to +121 degrees C -20 to +250 degrees F. The rated Kv (Cv) for butterfly valves shall be the value Kv (Cv) at 70 percent (60 degrees) open position. Valve leakage shall meet FCI 70-2 Class VI leakage rating.

2.6.3 Two-Way Valves

Two-way modulating valves used for liquids shall have an equal-percentage characteristic. Two-way modulating valves used for steam 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 provided 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 100 mm 4 inches and larger shall be butterfly valves.

2.6.7 Valves for High-Temperature Water, Hot-Water and Dual Temperature Service

a. Valves for hot water service between 99 and 121 degrees C 210 and 250 degrees F 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 degrees C 210 degrees F shall be brass, bronze or Type 316 stainless steel. Nonmetallic valve parts shall be suitable for a minimum continuous operating temperature of 121 degrees C or 28 degrees C 250 degrees F or 50 degrees F above the system design temperature, whichever is higher. Valves 100 mm 4 inches and larger shall be butterfly valves.

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

2.6.8 Valves for Steam Service

Bodies for valves 100 mm 4 inches 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.

2.7 DAMPERS

2.7.1 Damper Assembly

A single damper section shall have blades no longer than 1.2 m 48 inch and shall be no higher than 1.8 m 72 inch. Maximum damper blade width shall be 203 mm 8 inch. 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 13 mm 1/2 inch 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 10 Pa 0.04 inches water gauge at 5.1 m/s 1,000 ft/min in the wide-open position. Frames shall not be less than 50 mm 2 inch in width. Dampers shall be tested in accordance with AMCA 500-D.

2.7.2 Operating Linkages

Operating links external to dampers, such as crank arms, connecting rods, and line shafting for transmitting motion from damper actuators to dampers, shall withstand a load equal to at least 300 percent of the maximum required damper-operating force without deforming. 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 crank arms shall control the open and closed positions of dampers.

2.7.3 Damper Types

****

NOTE: As of July 2009, UFC 4-010-01 requires a maximum OA damper leakage of 3 cfm per square foot at 1 iwc static, which is a Class 1A damper. If this UFC or a similar requirement for a low-leakage damper is applicable to the project select Class 1A.

Otherwise:
1) If the application is in a very cold climate or where the system runs continuously consider selecting Class 1.

2) In other flow control applications select Class 2

For reference only, AMCA 511 leakage classifications at 4 iwc (1017 Pa) static are:
Class 1A: N/A.

Class 1: 8 cfm per square foot (40.6 L/s per square meter) of damper area.

Class 2: 20 cfm per square foot (102 L/s per square meter) of damper area.

Class 3: 80 cfm per square foot (406 L/s per square meter) of damper area.

AMCA 511 leakage classifications at 1 iwc (256 Pa) static are:
Class 1A: 3 cfm per square foot (15.2 L/s per square meter) of damper area.

Class 1: 4 cfm per square foot (20.3 L/s per square meter) of damper area.

****

2.7.3.1 Flow Control Dampers

Outside air, return air, relief air, exhaust, face and bypass 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. The channel frames of the dampers shall be provided with jamb seals to minimize air leakage. Unless otherwise shown, dampers shall meet AMCA 511 [Class 1A][Class 1][Class 2] requirements. 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 10 m/s 2000 ft/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 511 class 3. Dampers shall be rated at not less than 7.6 m/s 1500 ft/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 degrees C 250 degrees F 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. Sensors and instrumentation, including their transmitters, shall meet or exceed the specified range.

2.8.1 Transmitters

The transmitter shall match the characteristics of the sensor. Transmitters providing analog values shall produce a linear 4-20 mAdc, 0-10 Vdc 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 Application Specific Controllers (ASCs) and shall meet all ASC requirements. (note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE)

2.8.2 Temperature Sensors

2.8.2.1 Sensor Ranges and Accuracy

Temperature sensors may be provided without transmitters. Temperature sensors, including transmitter if used, shall have minimum operating ranges, minimum accuracy and maximum drift as specified below for the application:

2.8.2.1.1 Conditioned Space Temperature

2.8.2.1.1.1 Operating Range

5 to 35 degrees C 40 to 95 degrees F

2.8.2.1.1.2 Accuracy

+/- 0.5 degrees C 1 degree F over the operating range

2.8.2.1.1.3 Drift

Maximum 0.5 degrees C 1 degree F per year.

2.8.2.1.2 Unconditioned Space Temperature

2.8.2.1.2.1 Operating Range

-7 to +66 degrees C 20 to 150 degrees F.

2.8.2.1.2.2 Accuracy

+/- 0.5 degrees C 1 degree F over the range of -1 to +55 degrees C 30 to 131 degrees F and +/- 2 degrees C 4 degrees F over the rest of the operating range.

2.8.2.1.2.3 Drift

Maximum 0.5 degrees C 1 degree F per year.

2.8.2.1.3 Duct Temperature

2.8.2.1.3.1 Operating Range

5 to 60 degrees C 40 to 140 degrees F.

2.8.2.1.3.2 Accuracy

+/- 1 degree C 2 degrees F.

2.8.2.1.3.3 Drift

Maximum 1 degree C 2 degrees F per year.

2.8.2.1.4 Outside Air Temperature

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

2.8.2.1.4.1 Operating Range

[_____] to [_____] degrees C degrees F.

2.8.2.1.4.2 Accuracy

a. +/- 1 degree C 2 degrees F over the range of -35 to +55 degrees C -30 to +130 degrees F.

b. +/- 0.5 degrees C 1 degree F over the range of -1 to +40 degrees C 30 to 100 degrees F.

2.8.2.1.4.3 Drift

Maximum 0.5 degrees C 1 degree F per year.

2.8.2.1.5 High Temperature Hot Water

2.8.2.1.5.1 Operating Range

65 to 232 degrees C 150 to 450 degrees F.

2.8.2.1.5.2 Accuracy

+/- 2 degrees C 3.6 degrees F.

2.8.2.1.5.3 Drift

Maximum +/- 1 degree C 2 degrees F per year.

2.8.2.1.6 Chilled Water

2.8.2.1.6.1 Operating Range

-1 to +38 degrees C 30 to 100 degrees F.

2.8.2.1.6.2 Accuracy

+/- 0.4 degrees C 0.8 degrees F over the range of 2 to 18 degrees C 35 to 65 degrees F and +/- 1 degree C 2 degrees F over the rest of the operating range.

2.8.2.1.6.3 Drift

Maximum 0.4 degrees C 0.8 degrees F per year.

2.8.2.1.7 Dual Temperature Water

2.8.2.1.7.1 Operating Range

-1 to +116 degrees C 30 to +240 degrees F.

2.8.2.1.7.2 Accuracy

+/- 1 degree C 2 degrees F.

2.8.2.1.7.3 Drift

Maximum 1 degree C 2 degrees F per year.

2.8.2.1.8 Heating Hot Water

2.8.2.1.8.1 Operating Range

21 to 121 degrees C 70 to 250 degrees F.

2.8.2.1.8.2 Accuracy

+/- 1 degree C 2 degrees F.

2.8.2.1.8.3 Drift

Maximum 1 degree C 2 degrees F per year.

2.8.2.1.9 Condenser Water

2.8.2.1.9.1 Operating Range

-1 to +54 degrees C 30 to 130 degrees F.

2.8.2.1.9.2 Accuracy

+/- 0.6 degrees C 1 degree F.

2.8.2.1.9.3 Drift

Maximum 0.6 degrees C 1 degree F 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 at least 3 meters 1 foot long per square meter 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, 50 mm 2 inch 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 non-saturating 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 percent 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 percent to 100 percent with an accuracy of +/- 3 percent. RH sensors shall function over a temperature range of -4 to +55 degrees C 25 to 130 degrees F and shall not drift more than 2 percent per year.

2.8.4 Carbon Dioxide (CO_2) Sensors

Carbon dioxide (CO_2) sensors shall measure CO_2 concentrations between 0 to 2000 parts per million (ppm) using non-dispersive infrared (NDIR) technology with an accuracy of +/- 75 ppm and a maximum response time of 1 minute. The sensor shall be rated for operation at ambient air temperatures within the range of 0 to 50 degrees C 32 to 122 degrees F and relative humidity within the range of 0 to 95 percent (non-condensing). The sensor shall have a maximum drift of 2 percent. The sensor chamber shall be manufactured with a non-corrosive material (such as gold-plating) that does not affect carbon dioxide sample concentration. Duct mounted sensors shall be provided with a duct probe designed to protect the sensing element from dust accumulation and mechanical damage.

2.8.5 Differential Pressure Instrumentation

2.8.5.1 Differential Pressure Sensors

Differential Pressure Sensor range shall be as shown or as required for the application. Pressure sensor ranges shall not exceed the high end range shown on the Points Schedule by more than 50 percent. The over pressure rating shall be a minimum of 150 percent of the highest design pressure of either input to the sensor. The accuracy shall be +/- 2 percent of full scale.

2.8.5.2 Differential Pressure Switch

The switch shall have a user-adjustable setpoint. The device shall be sized for the application such that the setpoint is between 25 percent and 75 percent of the full range. The over pressure rating shall be a minimum of 150 percent 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 rating greater than it's connected load. Contacts shall open or close upon rise of pressure above the setpoint or drop of pressure below the setpoint as shown.

2.8.6 Flow Sensors

2.8.6.1 Airflow Measurement Array (AFMA)

2.8.6.1.1 Airflow Straightener

AFMAs shall contain an 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 AFMA 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 3 mm 0.125 inch aluminum honeycomb and the depth of the straightener shall not be less than 40 mm 1.5 inches.

2.8.6.1.2 Resistance to Airflow

The resistance to air flow through the AFMA, including the airflow straightener shall not exceed 20 Pa 0.08 inch water gauge at an airflow of 10 m/s 2,000 fpm. AFMA construction shall be suitable for operation at airflows of up to 25 m/s 5,000 fpm over a temperature range of 4 to 49 degrees C 40 to 120 degrees F.

2.8.6.1.3 Outside Air Temperature

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

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 degrees C-20 +120 degrees F] [_____].

2.8.6.1.4 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.

2.8.6.1.4.1 Airflows Over 3.0 m/s 600 fpm

Pitot Tube AFMAs for use in airflows over 3.0 m/s 600 fpm shall have an accuracy of +/- 5 percent over a range of 2.5 to 12.5 m/s 500 to 2,500 fpm.

2.8.6.1.4.2 Airflows Over 3.0 m/s 600 fpm

Pitot Tube AFMAs for use in airflows under 3.0 m/s 600 fpm shall have an accuracy of +/- 5 percent over a range of 0.6 to 12.5 m/s 125 to 2,500 fpm.

2.8.6.1.5 Electronic AFMA

Each electronic AFMA shall consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type. 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. Electronic AFMAs shall have an accuracy of +/- 5 percent percent over a range of 0.6 to 12.5 m/s 125 to 2,500 fpm and the output shall be temperature compensated over a range of 0 to 100 degrees C 32 to 212 degrees F.

2.8.6.2 Orifice Plate

Orifice plate shall be made of an austenitic stainless steel sheet of 3.3 mm 0.125 inch nominal thickness with an accuracy of +/- 1 percent of full flow. The orifice plate shall be flat within 0.1 mm 0.002 inches. The orifice surface roughness shall not exceed 0.5 micro-meters 20 micro-inches. The thickness of the cylindrical face of the orifice shall not exceed 2 percent of the pipe inside diameter or 12.5 percent 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.

2.8.6.3 Flow Nozzle

Flow nozzle shall be made of austenitic stainless steel with an accuracy of

+/- 1 percent 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.

2.8.6.4 Venturi Tube

Venturi tube shall be made of cast iron or cast steel and shall have an accuracy of +/- 1 percent 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 50 micro inch finish, including the short curvature leading from the converging entrance section into the throat.

2.8.6.5 Annular Pitot Tube

Annular pitot tube shall be made of austenitic stainless steel with an accuracy of +/- 2 percent of full flow and a repeatability of +/- 0.5 percent of measured value. The unit shall have at least one static port and no less than four total head pressure ports with an averaging manifold.

2.8.6.6 Insertion Turbine Flowmeter

Insertion Turbine Flowmeter accuracy shall be +/- 1 percent of reading for a minimum turndown ratio of 1:1 through a maximum turndown ratio of 50:1. Repeatability shall be +/- 0.25 percent of reading. The meter flow sensing element shall operate over a range suitable for the installed location with a pressure loss limited to 1 percent 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.

2.8.6.7 Vortex Shedding Flowmeter

Vortex Shedding Flowmeter accuracy shall be within +/- 0.8 percent 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.

2.8.6.8 Positive Displacement Flow Meter

The flow meter shall be a direct reading, gerotor, nutating disc 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 [liters] [gallons], and a sweep-hand dial to indicate down to 1 liter 0.25 gallons. 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 percent of the flow range. The maximum pressure drop at full flow shall be 34 kPa 5 psig.

2.8.6.9 Flow Meters, Paddle Type

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

2.8.6.10 Flow Switch

Flow switch shall have a repetitive accuracy of +/- 10 percent of actual flow setting. Switch actuation shall be adjustable over the operating flow range, and shall be sized for the application such that the setpoint is between 25 percent and 75 percent of the full 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.

2.8.6.11 Gas Utility Flow Meter

Gas utility flow meter shall be diaphragm or bellows type (gas positive displacement meters) for flows up to 19.7 L/sec 2500 SCFH and axial flow turbine type for flows above 19.7 L/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 percent 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 not require field adjustment or calibration. The electrical impulse dry contact output shall have a minimum resolution of 3 cubic meters 100 cubic feet of gas per pulse and shall not exceed 15 pulses per second at the design flow.

2.8.7 Electrical Instruments

Electrical Instruments shall have an input range as shown or sized for the application. Unless otherwise specified, AC instrumentation shall be suitable for 60 Hz operation.

2.8.7.1 Watt or Watthour Transducers

Watt transducers shall measure voltage and current and shall output kW or kWh or both kW and kWh as shown. kW outputs shall have an accuracy of +/- 0.25 percent over a power factor range of 0.1 to 1. kWh outputs shall be SNVT outputs or pulse outputs and shall have an accuracy of +/- 0.5 percent over a power factor range of 0.1 to 1.

2.8.7.2 Watthour Revenue Meter (with and without Demand Register)

****

NOTE: The intent of including meters in this Section is for energy monitoring as may be required for interface to a UMCS. Meters are typically only required by this Section for retrofit applications.

Coordination of meter installation and meter requirements with other specifications may be required.

Select the revenue meter accuracy as required for the application. For most applications, the 0.5 accuracy class should be suitable/sufficient. (Note the 0.5 accuracy class allows a 0.5 percent error, while the 0.2 class allows 0.2 percent).

****

All Watthour revenue meters shall measure voltage and current and shall be in accordance with ANSI C12.1 with an ANSI C12.20 Accuracy class of [0.5] [0.2] and shall have pulse initiators for remote monitoring of Watthour consumption. 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 NEMA/ANSI C12.10. Watthour revenue meters with demand registers shall have an analog output or SNVT output for instantaneous demand in addition to the pulse initiators.

2.8.7.3 Current Transducers

****

NOTE: Select the required accuracy for current transducers. Note that higher accuracy transducers will be more expensive and will likely require a more expensive/better quality controller.

****

Current transducers shall accept an AC current input and shall have an accuracy of +/- [0.5] [2]percent of full scale. The device shall have a means for calibration.

2.8.7.4 Current Sensing Relays (CSRs)

Current sensing relays (CSRs) shall provide a normally-open contact with a voltage and amperage rating greater than its connected load. Current sensing relays shall be of split-core design. The CSR shall be rated for operation at 200 percent of the connected load. Voltage isolation shall be a minimum of 600 volts. The CSR shall auto-calibrate to the connected load.

2.8.7.5 Voltage Transducers

Voltage transducers shall accept an AC voltage input and have an accuracy of +/- 0.25 percent of full scale. The device shall have a means for calibration. Line side fuses for transducer protection shall be provided.

2.8.8 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 kPa at 66 degrees C 100 psig at 150 degrees F. 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 +/- 0.05 pH value, response of 90 percent of full scale in one second and a linearity of 99 percent of theoretical electrode output measured at 24 degrees C 76 degrees F.

2.8.9 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. Sensor probe temperature rating shall be 435 degrees C 815 degrees F. The sensor assembly shall be equipped for flue flange mounting.

2.8.10 Carbon Monoxide Analyzer

****

NOTE: Enter the range for the CO 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 percent value. Unit measurement range shall not exceed specified range by more that 50 percent. Repeatability shall be +/- 2 percent of full scale with an accuracy of +/- 3 percent of full scale.

2.8.11 Occupancy Sensors

****

NOTE: Avoid using occupancy sensors with instant start fluorescent ballasts for instant start of lamps because they shorten the lamp life. Use only rapid start fluorescent ballasts.

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 mounted 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.

****

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 5 to 35 degrees C 40 to 95 degrees F or temperatures normally encountered in the installed location. 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 UL listed. In addition to any outputs required for lighting control, the occupancy sensor shall provide a dry contact output rated at 1A at 24 Vac or a SNVT output.

2.8.11.1 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 detection of at least 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.

2.8.11.2 Ultrasonic Occupancy Sensors

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

2.8.11.3 Dual-Technology Occupancy Sensor (PIR and Ultrasonic)

Dual-Technology Occupancy Sensors shall meet the requirements of both PIR and Ultrasonic Occupancy Sensors.

2.8.12 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 percent of setting with repeatability of plus or minus 2 percent.

2.8.13 Conductivity Sensor

****

NOTE: Remove the bracketed text for new construction (Contractor cannot meet this requirement). For retrofit projects, coordinate with the project site to determine need for this analysis.

****

Sensor shall include local indicating meter and shall be 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 (µS/cm) for distillation systems, 0 to 100 µS/cm for boiler, chilled water, and potable water systems and 0 to 1000 µS/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 output shall be temperature compensated over a range of 0 to 100 degrees C 32 to 212 degrees F. The accuracy shall be +/- 2 percent of the full scale reading. Sensor shall have automatic zeroing and shall require no periodic maintenance or recalibration.

2.8.14 Compressed Air Dew Point Sensor

Sensor shall be suitable for measurement of dew point from -40 +27 degrees C -40 +80 degrees F over a pressure range of 0 to 1 MPa 0 to 150 psig. 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 degrees C 5 degrees F and the dry bulb shall be +/- 0.6 degrees C 1 degree F. Sensor shall be automatic zeroing and shall require no normal maintenance or periodic 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 percent oxygen basis and shall have a range of from 0 to 100 ppm. Sensor shall be accurate to +/- 5 ppm. Sensor shall output NOx and oxygen levels and binary output that changes state when the NOx level is 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 not require periodic maintenance or recalibration.

2.8.16 Turbidity Sensor

Sensor shall include a local indicating meter and shall be 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 output shall be temperature compensated over a range of 0 to 100 degrees C 32 to 212 degrees F. The accuracy shall be +/- 5 percent of full scale reading. Sensor shall have automatic zeroing and shall not require periodic maintenance or recalibration.

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 percent of full scale and an accuracy of +/- 2 percent of full scale. The Chlorine Detector transmitter shall be housed in a non-corrosive 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 Detector

Leak detectors shall use electrodes mounted at slab level with a minimum built-in-vertical adjustment of 3 mm 0.125 inches. Detector shall have a binary output. The indicator shall be manual reset type.

2.8.19 Temperature Switch

2.8.19.1 Duct Mount Temperature Low Limit Safety Switch (Freezestat)

Duct mount temperature low limit switches (Freezestats) shall be manual reset, low temperature safety switches at least 3 meters 1 foot long per square meter square foot of coverage which shall respond to the coldest 450 mm 18 inch segment with an accuracy of +/- 2 degrees C 3.6 degrees F. The switch shall have a field-adjustable setpoint with a range of at least -1 +10 degrees C 30 to 50 degrees F. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon drop of temperature below setpoint as shown and shall remain in this state until reset.

2.8.19.2 Pipe Mount Temperature Limit Switch (Aquastat)

Pipe mount temperature limit switches (aquastats) shall have a field adjustable setpoint between 15 and 32 degrees C 60 and 90 degrees F, an accuracy of +/- 2 degrees C 3.6 degrees F and a 5 degrees C 10 degrees F fixed deadband. The switch shall have two sets of contacts, and each contact shall have a rating greater than its connected load. Contacts shall open or close upon change of temperature above or below setpoint as shown.

2.8.20 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.

2.9 INDICATING DEVICES

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

2.9.1 Thermometers

Thermometers shall not contain mercury. Unless otherwise specified, thermometers shall have an accuracy of +/- 3 percent of scale range. Thermometers shall have a range suitable for the application with an upper end of the range not to exceed 150 percent 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 230 mm 9 inch scale. Piping system thermometers shall have an accuracy of +/- 1 percent of scale range. 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 percent of the design upper limit. Accuracy shall be +/- 3 percent of scale range. Gauges shall meet requirements of ASME B40.100.

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 percent 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 requirements in addition to the output device requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE.)

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.

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 Points 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 (FILP) 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 Transducer (EP). Electric actuators shall have a full stroke response time in both directions 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 172 kPa 25 psi operating pressure except for high-pressure cylinder-type actuators.] All actuators shall be rated for their operating environment. Actuators used outdoors shall be designed and rated for outdoor use. Actuators under continuous exposure to water, such as those used in sumps, shall be submersible.

2.10.1.1 Valve Actuators

****
NOTE: Indicate in the Valve Schedule a close-off pressure that is 150 percent of the pump dead head pressure for 2-way valves and 200 percent of the valve differential pressure for 3-way valves, or equivalent torque values.
****

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

2.10.1.2 Damper Actuators

Damper actuators shall provide the torque necessary per damper manufacturer's instructions to modulate the dampers smoothly over its full range of operation and torque shall be at least 7.3 Nm/square m 6 inch-pounds/1 square foot of damper area for opposed blade dampers and 10.9 Nm/square m 9 inch-pounds/1 square foot of damper area for parallel blade dampers.

2.10.1.3 Positive Positioners

****
NOTE: Positive positioners *may* be required for larger valves and actuators or where high-speed actuation is needed. 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 3-410-02for 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 10 mm 0.38 inch NPT threaded connection. Valves shall be rated for 345 kPa 50 psig.

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 4-20 mAdc input signal, a 0-10 Vdc input signal, or SNVT input to a 21-103 kPa 3-15 psig pneumatic output with a conversion accuracy of +/- 2 percent of full scale, including linearity and hysteresis. The EP shall withstand pressures at least 150 percent of the system supply air pressure (main air). EPs shall include independent offset and span adjustment. Steady state air consumption shall not be greater than 0.024 L/s 0.05 scfm. EPs shall have a manual adjustable override for the EP pneumatic output. EPs shall have sufficient output capacity to provide full range 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 dust proof 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 percent of rated coil voltage.

2.11 USER INPUT DEVICES

User Input Devices, including potentiometers, switches and momentary contact push-buttons with SNVT output are Application Specific Controllers (ASCs) and shall meet all ASC requirements. (Note: ASCs are specified in paragraph DIRECT DIGITAL CONTROL (DDC) HARDWARE). Potentiometers shall be of the thumb wheel or sliding bar type. Momentary Contact Push-Buttons may include an adjustable timer for their output. User input devices shall be labeled for their function.

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

****

NOTE: Indicate requirements for each thermostat on the Thermostat and Occupancy Sensor drawing.

****

Thermostats shall be multifunction devices incorporating a temperature sensor and one or more of the following as specified and shown on the Thermostat Schedule:

a. A temperature indicating device.

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

c. A User Input Momentary Contact Button and an output to the control system indicating zone occupancy.

d. A three position User Input Switch labeled to indicate heating, cooling and off positions ('HEAT-COOL-OFF' switch) and providing corresponding outputs to the control system.

e. A two position User Input Switch labeled with 'AUTO' and 'ON' positions and providing corresponding output to the control system..

f. A multi-position User Input Switch with 'OFF' and at least two fan speed positions and providing corresponding outputs to the control system.

Thermostats containing mercury (Hg) are prohibited.

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 1380 kPa 200 psi 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 140 kPa 20 psi. 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 483 kPa 70 psi 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 pre-filter 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 1034 kPa 150 psi 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 1034 kPa and 120 degrees C 150 psi and 250 degrees F service, and shall be constructed of rubber or tetrafluoroethylene resin tubing with a reinforcing protective cover of 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 to indicate the device is receiving power.

c. It shall incorporate a TP/FT-10 transceiver in accordance with CEA-709.3 and connections for TP/FT-10 control network wiring.

d. It shall communicate on the network using only the CEA-709.1-D protocol.

e. It shall be capable of having network communications configured via LNS.

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

f. It shall be locally powered; link powered devices are not acceptable.

g. LonMark external interface files (XIF files), as defined in the LonMark XIF Guide, shall be submitted for each type of DDC Hardware. External interface files (XIF files) shall be submitted as a technical data package for each model of DDC Hardware provided under this specification. XIF files shall be submitted on optical disk.

h. Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings:

(1) Loss of power shall never result in the loss of application programs, regardless of the length of time power is lost (i.e. application programs shall be stored in non-volatile memory).

(2) Loss of power for less than 72 hours shall not result in the loss of configuration settings.

i. It shall have all functionality specified and required to support the application (Sequence of Operation or portion thereof) in which it is used, including but not limited to:

(1) It shall provide input and output SNVTs as specified, as shown on the Points Schedule, and as otherwise required to support the sequence and application in which it is used. All SNVTs shall have meaningful names identifying the value represented by the SNVT. Unless a SNVT of an appropriate engineering type is not available, all network variables shall be of a standard network variable type with engineering units appropriate to the value the variable represents.

(2) It shall be configurable via standard configuration properties (SCPTs) as defined in the LonMark SCPT List, user-defined configuration properties (UCPTs), network configuration inputs (*nci* s) of a SNVT type as defined in the LonMark SNVT List, network configuration inputs (*ncis*) of a user defined network variable type, or hardware settings on the controller itself for all settings and parameters used by the application in which it is used.

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

****
NOTE: FYI - The following requires that contractors with hardware that could be submitted under several categories to choose which requirements they must meet. This ensures that the device is evaluated according to its actual use.
****

k. In addition to these general requirements and the DDC Hardware Input-Output (I/O) Function requirements, all DDC Hardware shall also meet the requirements of either a Local Display Panel (LDP), Application Specific Requirement (ASC), General Purpose Programmable Controller (GPPC), or Application Generic Controller (AGC). All pieces of DDC Hardware shall have their DDC Hardware Type identified in the Manufacturer's Catalog Data submittal. Where a single device meets the requirements of multiple types, select a single type for that specific device based on it's use. One model of DDC hardware may be submitted as different DDC Hardware types when used in multiple applications.

l. The user interface on all DDC Hardware with a user interface shall be password protected against changes.

2.14.2 Hardware Input-Output (I/O) Functions

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

2.14.2.1 Analog Inputs

DDC Hardware analog inputs (AIs) shall perform analog to digital (A-to-D) conversion with a minimum resolution of 8 bits plus sign or better as needed to meet the accuracy requirements specified in paragraph INPUT MEASUREMENT ACCURACY. Signal conditioning including transient rejection shall be provided for each analog input. Analog inputs shall be capable of being individually calibrated for zero and span. The AI shall incorporate common mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10,000 ohms.

2.14.2.2 Analog Outputs

****
NOTE: PART 3 of this section and the Points Schedules may require that points have an H-O-A switch. For analog outputs these switches may be "full on, full off" overrides or may have a knob

allowing for override to any value (0-100 percent). Unless the project site specifically requires that analog outputs be fully adjustable through the range 0-100 percent, keep the bracketed text allowing either option (i.e. keep "to 0 percent and to 100 percent". Requiring fully adjustable overrides (i.e. "through the range of 0 percent to 100 percent") will likely raise the cost of the system.

****

DDC Hardware analog outputs (AOs) shall perform digital to analog (D-to-A) conversion with a minimum resolution of 8 bits plus sign, and output a signal with a range of 4-20 mAdc or 0-10 Vdc. Analog outputs shall be capable of being individually calibrated for zero and span. DDC Hardware with Hand-Off-Auto (H-O-A) switches for analog outputs shall provide for overriding the output [to 0 percent and to 100 percent][through the range of 0 percent to 100 percent].

2.14.2.3 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 180 Vac peak shall be provided.

2.14.2.4 Binary Outputs

DDC Hardware binary outputs (BOs) shall provide relay contact closures or triac outputs for momentary and maintained operation of output devices. DDC Hardware with H-O-A switches for binary outputs shall provide for overriding the output open or closed.

2.14.2.4.1 Relay Contact Closures

Closures shall have a minimum duration of 0.1 second. Relays shall provide at least 180V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be one ampere at 24 Vac.

2.14.2.4.2 Triac Outputs

Triac outputs shall provide at least 180 V of isolation. Minimum contact rating shall be one ampere at 24 Vac.

2.14.2.5 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 of at least 20 pulses per second. The totalized value shall be reset to zero upon operator's command.

2.14.3 Local Display Panel (LDP)

The Local Display Panels (LDPs) shall be DDC Hardware with a display and navigation buttons, and shall provide display and adjustment of SNVT inputs and SNVT outputs as shown on the Points Schedule and as specified. The adjustment of SNVTs shall be password protected.

2.14.4   Application Specific Controller (ASC)

Application Specific Controllers (ASCs) have a fixed factory-installed application program (i.e. ProgramID) with configurable settings and do not have the ability to be programmed for custom applications.. 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. Unless otherwise approved, all necessary Configuration Properties and network configuration inputs (*nci*s) for the sequence and application in which the ASC is used shall be fully configurable through an LNS plug-in. LNS Plug-ins for each Application Specific Controller and each Application Generic 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 optical disk. Hard copy manuals, if available, shall be submitted for each plug-in provided. This plug-in shall be submitted for each type of ASC (manufacturer and model). (Note: configuration accomplished via hardware settings does not require configuration via plug-in.)

c. ASCs may be include an integral or tethered Local Display Panel

2.14.5   General Purpose Programmable Controller (GPPC)

A General Purpose Programmable Controller (GPPC) may or may not be furnished with a fixed factory-installed application program and must be programmed for the application. GPPCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

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

b. All programming software required to program the GPPC shall be delivered to and licensed to the project site. Submit the most recent version of the Programming software for each type (manufacturer and model) of General Purpose Programmable Controller (GPPC) as a Technical Data Package. Software shall be submitted on optical disk and [_____] hard copies of the software user manual shall be submitted for each piece of software provided.

****

NOTE: FYI: The requirement to submit source code is vital to allow the Government to maintain the system and modify or reprogram devices if needed. The intent is that the Government can both:

1) modify the source code and re-download to the controller to change the sequence

2) buy an unprogrammed identical replacement controller and download the program into it in order to replace the controller

****

c. Submit copies of the installed GPPC application programs (all software that is not common to every controller of the same manufacturer and model) as source code compatible with the supplied programming software. The submitted GPPC application program shall be the complete application necessary for the GPPC to function as installed and be sufficient to allow replacement of the installed controller with a GPPC of the same type. All installed GPPC Application Programs shall be submitted on optical disk as a Technical Data Package. The optical disk shall include a list or table of contents clearly indicating which application program is associated with each device. Submit [2] [_____] copies of the GPPC Application Program's optical disk.

d. GPPCs may be include an integral or tethered Local Display Panel

2.14.6 Application Generic Controller (AGC)

An Application Generic Controller (AGC) has a fixed application program which includes the ability to be programmed for custom applications. AGCs shall meet the following requirements in addition to the general DDC Hardware requirements and Hardware Input-Output (I/O) Functions:

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

b. The AGC shall have a fixed ProgramID and fixed XIF file.

c. Unless otherwise approved, the ACG shall be fully configurable and programmable for the application using one or more LNS plug-ins, all of which shall be submitted as specified for each type of AGC (manufacturer and model).

d. Submit copies of the installed AGC application programs as source code compatible with the supplied programming software LNS plug-in. The submitted AGC application program shall be the complete application program necessary for the AGC to function as installed and be sufficient to allow replacement of the installed controller with an AGC of the same type. All installed AGC Application Programs shall be submitted on optical disk as a Technical Data Package. The optical disk shall include a list or table of contents clearly indicating which application program is associated with each device. Submit [2] [_____] copies of the AGC Application Program's optical disk.

****

NOTE: FYI: The requirement to submit source code is vital to allow the Government to maintain the system and modify or reprogram devices if needed. The intent is that the Government can both:

1) modify the source code and re-download to the controller to change the sequence

2) buy an unprogrammed identical replacement controller and download the program into it in order to replace the controller

****

e. AGCs may be include an integral or tethered Local Display Panel

PART 3 EXECUTION

3.1 EXISTING CONDITIONS SURVEY

****

NOTE: Use the bracketed text for retrofit projects only. For new construction, the existing conditions survey may not be required and may be removed (be sure to remove the report from the submittals as well). Keeping it as a requirement, however, will ensure that the Contractor checks the mechanical equipment prior to beginning controls installation. This should allow problems to be caught and addressed earlier.

****

Perform a field survey, including testing and inspection of the equipment to be controlled and submit [4] [_____] copies of the Existing Conditions Report documenting the current status and its impact on the Contractor's ability to meet this specification. For those items considered nonfunctional, provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated costs to correct the deficiencies. As part of the report, define the scheduled need date for connection to existing equipment. Make written requests and obtain Government approval prior to disconnecting any controls and obtaining equipment downtime. Existing devices which are not to be replaced shall be inspected, calibrated, and adjusted as necessary to place them in proper working order.

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, commissioned, 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 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

All devices shall be installed in accordance with manufacturer's recommendations and as specified and 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. All Enclosures and DDC Hardware shall be labeled. All sensors and actuators in mechanical rooms shall be 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 and mechanically attached to the enclosure or DDC Hardware. Labels inside protective enclosures may attached using adhesive, but shall not be hand written.

3.2.2 Building Control Network (BCN)

Provide one or more Building Control Networks (BCNs) as required to connect all DDC hardware to a Building Control Network and to meet bandwidth requirements as specified. This requirement may result in multiple BCNs being installed, and unless otherwise specified or necessary to provide required functionality these BCNs may remain separate. Each building control network consists of one or more channels, one of which is the BCN backbone.

3.2.2.1 Building Control Network (BCN) Channel

Each BCN channel shall meet the following requirements:

a. Each channel shall be a TP/FT-10 channel in doubly terminated bus topology in accordance with CEA-709.3.

b. Each channel shall contain no more than 2/3 the maximum number of devices permitted by CEA-709.3.

c. Each channel shall contain no more than 2/3 the maximum number of devices permitted by the manufacturer of the device transceivers. When more than one type of transceiver is used on the same channel the channel shall contain no more than 2/3 of the maximum devices for the transceiver with the lowest maximum.

d. Physical layer repeaters shall not be used.

3.2.2.2 Building Control Network (BCN) Backbone

Each Building Control Network shall have a single BCN Backbone meeting the following requirements:

a. The BCN Backbone shall meet all requirements of a BCN channel except as specified here.

b. When a BCN consist of only a single channel, that channel shall be the Backbone.

c. When a BCN consists of multiple channels, one channel shall be the BCN Backbone, and this channel may be either TP/FT-10 or TP/XF-1250 in accordance with the LonMark Interoperability Guide. The BCN Backbone shall have no devices except CEA-709.1-D Routers connected to it. DDC Hardware shall not be connected to the BCN Backbone when more than one channel is provided.

3.2.2.3 Building Control Network (BCN) Installation

Each building control network shall meet the following requirements:

a. All DDC Hardware shall be connected to a BCN Channel

b. No DDC Hardware shall have more than two CEA-709.1-D Routers between it and a BCN Backbone

****

NOTE: Coordinate with the project site to determine if the CEA-709.1-D to IP Router should be installed as part of this project. Normally this is installed by the contractor performing integration of the building control system into the UMCS (per Section 25 10 10) but some sites prefer to include this requirement as part of the building control system.

Also select the appropriate bracketed options to indicate whether the BPOC location is shown on a drawing or to specify the BPOC location here.

In order to meet Information Assurance (IA) requirements, require the CEA-709.1-D to IP Router be installed in a lockable enclosure unless the BPOC location itself is secure (e.g. in a locked telecommunications closet).

****

c. [Each BCN Backbone shall be available at the Building Point of Connection (BPOC) location [as shown][_____]. When the BPOC location is a room number, provide sufficient additional backbone media to ensure that the BCN Backbone can be extended to any location in the room.][Provide a CEA-709.1-D to IP Router [in an enclosure][in a lockable enclosure] at the BPOC Location [as shown][_____] and connect the BCN Backbone to it. Do not connect the CEA-709.1-D to IP Router to an IP network.]

d. The peak expected bandwidth usage for each and every channel shall be less than 70 percent, including device-to-device traffic and traffic to the Utility Monitoring and Control System (UMCS) as shown on the Points Schedule. Note that all network traffic to the UMCS is present on the BCN Backbone.

e. The BCN's backbone shall be tagged and labeled at the BPOC location with the expected bandwidth usage and the bandwidth usage measured during the PVT.

f. Where multiple pieces of DDC Hardware are used to execute one sequence all DDC Hardware executing that sequence shall be on a [dedicated]single channel.

3.2.3 DDC Hardware

****

NOTE: Coordinate with the project site for preference on the use of programmable controllers or multiple application specific controllers in cases where a single application specific controller for the application is not available.

****

DDC hardware shall not be connected to a BCN Backbone if that building control network has more than one channel. Except for DDC Hardware in suspended ceilings, install all DDC Hardware in an enclosure. All DDC Hardware shall be configured and commissioned on the Building Control

Network via LNS using an LNS-based Network Configuration Tool. Controllers shall be Application Specific Controllers whenever an Application Specific Controller suitable for the application exists. When an Application Specific Controller suitable for the application does not exist use [Application Generic Controllers, General Purpose Programmable Controllers or multiple Application Specific Controllers][Application Generic Controllers or General Purpose Programmable Controllers][multiple Application Specific Controllers].

3.2.3.1 Hand-Off-Auto (H-O-A) Switches

****

NOTE: See also DDC Hardware in PART 2.

The bracketed text is a general requirement for H-O-A switches and should only be included if such a requirement is necessary. It is best practice to remove the bracketed text and indicate which points require H-O-A switches on the Points Schedules. Note that many sequences already have H-O-A switch requirements for motors.

****

Hand-Off-Auto (H-O-A) switches shall be provided [for all DDC Hardware analog outputs and binary outputs used for control of systems other than terminal units,]as specified and as shown on the Points Schedule. H-O-A switches shall be integral to the controller hardware, an external device co-located with (in the same enclosure as) the controller, integral to the controlled equipment, or an external device co-located with (in the same enclosure as) the controlled equipment.

a. H-O-A switches integral to DDC Hardware shall meet the requirements specified in DDC Hardware.

b. H-O-A switches for binary outputs shall provide for overriding the output open or closed.

c. H-O-A switches for analog outputs shall provide for overriding through the range of 0 percent to 100 percent.

3.2.3.2 Local Display Panels

****

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

Designer should coordinate with the project site to determine number and location of LDPs needed and show on them on the drawings. Due to limitations of LDPs, the project site may opt to not specify LDPs and use a laptop instead.

****

Local Display Panels shall be provided [in each mechanical room containing an air handler][_____] and shall provide SNVT inputs for display and outputs for adjusting SNVT values as shown on the Points Schedule.[Locate LDPs in the mechanical room closest to the equipment providing information displayed by the LDP.]

3.2.3.3 Overrides for GPPCs and AGCs

****
NOTE: The following methods of implementing overrides are intended to be used for overriding setpoints and outputs. They will also work to override inputs, but the use of overrides on inputs is strongly discouraged since the operator loses all indication of the actual state of the system (e.g. Operator overrides zone temperature to 65 to force heating, zone heats up to 85 and operator has no indication that it's hot in the zone).
****

Provide the capability to override points for all General Purpose Programmable Controllers and Application Generic Controllers as specified and as shown on the Points Schedule using one of the following methods:

3.2.3.3.1 Override SNVT of Same SNVT Type Method

a. Use this method for all setpoint overrides and for overrides of inputs and outputs whenever practical.

b. Provide a SNVT input to the DDC hardware containing the point to be overridden of the same SNVT type as the point to be overridden.

c. Program and configure the DDC hardware such that:

   (1) If the value of the SNVT on the override input is the *Invalid Value* defined for that SNVT by the LonMark SNVT List, then the point is not overridden (its value is determined from the sequence).

   (2) If the value of the SNVT on the override input is not the *Invalid Value* defined for that SNVT by the LonMark SNVT List then set the value of the point to be overridden to the value of the SNVT on the override input.

3.2.3.3.2 HVAC Override SNVT Method

a. Use this method for override of inputs and outputs when the "Override SNVT Shares SNVT Type" method is impractical.

b. Provide a SNVT input to the DDC hardware containing the point to be overridden of SNVT type *SNVT_hvac_overid.* Show on the Points Schedule how to perform the specified override using this SNVT.

3.2.3.4 Overrides for ASCs

Whenever possible use the methods specified for General Purpose Programmable Controllers and Application Generic Controllers to perform overrides for all Application Specific Controllers. If neither the "Override SNVT of Same SNVT Type" method or "HVAC Override SNVT" method are supported by the Application Specific Controller show this on the Points Schedule and perform overrides as follows:

a. Provide one or more SNVT input(s) to the DDC hardware containing the point to be overridden. Document the number and type of each SNVT provided on the Points Schedule.

b. Configure the Application Specific Controller such that:

(1) For some specific combination or combinations of values at the SNVT override input(s) the point is not overridden, and its value is determined from the sequence as usual. Show on the Points Schedule the values required at the SNVT override input(s) to not override the point.

(2) For other specific combinations of SNVT override input(s), the value of the point to be overridden is determined from the value of the override input(s). Show on the Points Schedule the correlation between the SNVT override input(s) and the resulting value of the overridden point.

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-CEA 709.1 network connected to a ACEA 709.1 network via a gateway.
****

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

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

b. Non-CEA-709.1-D control hardware shall not be used for controlling built-up units.

c. Non-CEA-709.1-D control hardware shall not perform system scheduling functions.

d. Non-CEA-709.1-D network wiring shall be installed only to connect the gateway to the package unit and shall not exceed 3 meters 10 feet in length.

3.2.5 Network Interface Jack

****
NOTE: Choose the preferred location for network interface jacks by controllers with thermostats (coordinate with the project site to determine preference of O&M Staff).

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

Provide standard network interface jacks such that each node on the control network is within 3 m 10 ft of an interface jack. For terminal unit controllers with hardwired thermostats this network interface jack may instead be located at the thermostat. Locating the interface jack [at the thermostat][near the controller] is preferred. If the network interface jack is other than a 3 mm 1/8 inch phone jack, provide an interface cable with a standard 3 mm 1/8 inch 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 [one] [_____] interface cable(s).

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, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 1.5 m 60 inches above the floor unless otherwise shown. Unless otherwise shown on the Thermostat Schedule:

a. Thermostats for Fan Coil Units shall be unit mounted.

b. All other Thermostats shall be wall mounted.

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 Smoke Detectors are installed by the fire alarm system Contractor. Duct detectors are intended to shut down air distribution fans and close smoke dampers where applicable. Each detector must be indicated on the schematic and associated ladder diagram.

Coordinate with the applicable Section 1385x used for the fire alarm system installation, to make sure that smoke detectors are installed in the proper location and that all detectors that are to be interfaced to the DDC system have auxiliary contacts for this purpose.

In the following paragraph indicate which Section is used for the installation of the fire alarm system (and the duct smoke detectors).

****

Duct smoke detectors will be provided in supply and return air ducts in accordance with [Section 28 31 64.00 10 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE][_____]. Connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.

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 1.8 m 6 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 detect motion to within 0.6 m 2 feet of all room entrances and shall not trigger due to motion outside the room. 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 Temperature Limit Switch

A temperature limit switch (freezestat) shall be provided to sense the temperature at the location shown. A sufficient number of temperature limit switches (freezestats) shall be installed to provide complete coverage of the duct section. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily. The temperature limit switch (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 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION AND EXHAUST SYSTEMS and installed by the Mechanical Contractor (not by the controls Contractor under this spec).

Pitot Tube AFMAs are traditionally not accurate at low flows and may not be suitable if MinOA ducts are not used. Some Pitot Tube AFMAs are now accurate at low flows and can be used provided they meet the specified product requirements (in Part 2).

****

Outside Air AFMAs shall be located downstream from the Outside Air filters.

3.2.13 Duct Static Pressure Sensors

The duct static pressure sensing tap shall be located at 75 percent to 100 percent of the distance between the first and last air terminal units. If the transmitter output is a 4-20 mA or 0-10Vdc signal, the transmitter shall be located in the same enclosure as the air handling unit (AHU) controller for the AHU serving the terminal units.

3.2.14 Relative Humidity Sensors

Relative humidity sensors in supply air ducts shall be installed at least 3 m 10 feet downstream of humidity injection elements.

3.2.15 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.

3.2.16 Dampers

3.2.16.1 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.

3.2.16.2 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 Valves

3.2.17.1 Ball Valves

Two-position (open/closed) ball valves may only be used on chilled water, condenser water, hot water, or steam applications. Modulating ball valves may only be used for chilled water and condenser water applications (modulating ball valves shall not be used on steam or hot water applications). In modulating applications a characterizing equal-percentage disc shall be used.

3.2.17.2 Butterfly Valves

In two-way control applications, valve travel shall be limited to 70 percent (60 degrees) open position.

3.2.18 Local Gauges for Actuators

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

3.2.19 Wire and Cable

****

NOTE: Coordinate with the project site and indicate whether all wiring needs to be in raceways or whether low-voltage wiring can be run without raceways.

Note that requiring all wiring to be run in raceways will increase the project cost.

****

Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. 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. Test installed ground rods as specified in IEEE 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 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown. Wiring external to enclosures shall be run in raceways[, except low-voltage control and low-voltage network wiring may be installed as follows:s:

a. plenum rated cable in suspended ceilings over occupied spaces may be run without raceways

b. nonmetallic-sheathed cables or metallic-armored cables may be installed as permitted by NFPA 70.]

3.2.20 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.

3.2.21 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 degrees C 130 degrees F. 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.

3.2.22 Pneumatic Lines

a. 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.

b. 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.

c. 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.

3.2.22.1 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 2 m 6 feet for horizontal runs and every 2.5 m 8 feet for vertical runs.

3.2.22.2 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 plastic tubing in raceways not containing power wiring or copper with sweat fittings . Raceways and tubing not in raceways shall be supported every 2.5 m 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 specified, may be used above accessible ceilings and in other concealed but accessible locations.

3.2.22.3 Terminal Single Lines

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

3.2.22.4 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.

3.2.22.5 Connection to Ductwork

Connections to sensing elements in ductwork shall be plastic tubing.

3.2.22.6 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.

3.2.22.7 Tubing Connection to Actuators

Final connections to actuators shall be plastic tubing no more than 300 mm 12 inches long and unsupported at the actuator.

3.2.23 Compressed Air Stations

****
NOTE: If possible, foundations and housekeeping pads should be specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.
****

Mount the air compressor assembly on vibration eliminators, in accordance with ASME BPVC SEC VIII D1 for tank clearance. Connect the air line to the tank with a flexible pipe connector. Install compressed air station specialties with required tubing, including condensate tubing to a floor drain. Compressed air stations shall deliver control air meeting the requirements of ISA 7.0.01. Provide foundations and housekeeping pads for the HVAC control system air compressors [in accordance with the air compressor manufacturer's instructions][as specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS].

3.3 DRAWINGS AND CALCULATIONS

Prepare and submit shop drawings.

3.3.1 DDC Contractor Design Drawings

****
NOTE: Most contractor drawings are updated Contract Drawings. Therefore, it is important that the contract drawing package is complete. Drawing package content is discussed in UFC 3-410-02 and template drawings are available online at https://eko.usace.army.mil/fa/bas/.

Many requirements in this specification refer to the Points Schedules so it is critical that complete Points Schedules are part of the Contract Drawings.

A Riser Diagram is not a required part of the Contract Drawings but you may wish to include a Riser Diagram in the contract drawings to show project specific requirements such as DDC Hardware

locations etc.

Decide whether to require a specific drawing size (approx 279x432 mm (11x17inch) or 557x860 mm (22x34 inch) or to leave it up to the Contractor.

****

Drawings shall be on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] 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. DDC Contractor Design Drawings shall be submitted together as a complete submittal in hard copy and on optical disk in [AutoCAD] [Microstation] format. Deviations shall be approved by the Contracting Officer. DDC Contractor Design Drawings shall include the following:

3.3.1.1 Drawing Index and HVAC Design Drawing Legend

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 all Design Drawings, including the drawing number, sheet number, drawing title, and computer filename when used. The Design Drawing Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings.

3.3.1.2 Valve Schedule

The valve schedule shall contain 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 to 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. Submit a valve schedule for each HVAC system.

3.3.1.3 Damper Schedule

The damper schedule shall contain each damper's unique identifier, type (opposed or parallel blade), nominal and actual sizes, orientation of axis and frame, direction of blade rotation, actuator size and spring ranges, operation rate, positive positioner range, location 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 511 maximum leakage rate at the operating static-pressure differential. Submit a damper schedule for each HVAC system.

3.3.1.4 Thermostat and Occupancy Sensor Schedule

The thermostat and occupancy sensor schedule shall contain each thermostat's unique identifier, room identifier and control features and functions as shown. Submit a thermostat and occupancy sensor schedule for each HVAC system.

3.3.1.5 Equipment Schedule

The equipment schedule shall contain the unique identifier, manufacturer, model number, part number and descriptive name for each control device, hardware and component provided under this specification. Submit an equipment schedule for each HVAC system.

3.3.1.6 Occupancy Schedule

The occupancy schedule drawing shall contain the same fields as the occupancy schedule Contract Drawing with Contractor updated information. Submit an occupancy schedule for each HVAC system.

3.3.1.7 Points Schedule

The Points Schedule drawing shall contain the same fields as the Points Schedule Contract Drawing with Contractor updated information, and at a minimum shall contain: Device address and NodeID, Input and Output SNVTs including SNVT Name, Type and Description, Hardware I/O, including Type (AI, AO, BI, BO) and Description. Submit a Points Schedule for each HVAC system.

3.3.1.8 Compressed Air Station Schematic

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 140 kPa 20 psig. Submit compressed air station schematic drawings for each compressed air station.

3.3.1.9 Riser Diagram of Building Control Network

The Riser Diagram of the Building Control Network may be in tabular form, and shall show all DDC Hardware and all Network Hardware, including network terminators. For each item, provide the unique identifier, common descriptive name, physical sequential order (previous and next device on the network), room identifier and location within room. Submit a single riser diagram for each building control network.

3.3.1.10 Control System Schematics

The control system schematics shall be in the same form as the control system schematic Contract Drawing with Contractor updated information. Submit a control system schematic for each HVAC system.

3.3.1.11 Sequences of Operation[Including Control Logic Diagrams]

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NOTE: Require Control Logic Diagrams if they have been included in the contract drawings.

****

The HVAC control system sequence of operation and [control logic diagrams] shall be in the same format as the Contract Drawings and shall refer to the devices by their unique identifiers. No operational deviations from specified sequences will be permitted without prior written approval of the Government. Submit sequences of operation[and control logic diagrams] for each HVAC control system.

3.3.1.12 Controller, Motor Starter and Relay Wiring Diagram

The controller wiring diagrams shall be functional wiring diagrams which show the interconnection of conductors and cables to each controller and to the identified terminals of input and output devices, 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. Show the connected volt-ampere load and the power supply volt-ampere rating. Submit wiring diagrams for each HVAC control system.

3.3.2 Draft As-Built Drawings

Update the Contractor Design Drawings with all as-built data and submit in hard copy and on optical disk in [AutoCAD] [Microstation] format.

3.3.3 Final As-Built Drawings

Update the Draft As-Built Drawings with all final as-built data and submit in hard copy and on optical disk in [AutoCAD] [Microstation] format.

3.4 HVAC SYSTEMS SEQUENCES OF OPERATION

****

NOTE: These sequences are 'template' sequences. When editing this specification, the sequences should be put onto the drawings and these template sequences should be deleted. Note that the Alarm Handling and Scheduling sequences each need to be edited and placed onto their own drawing.

When removing the sequences, keep this subpart number and title intact, but replace the entire contents of the subpart with a note such as *"All Sequences of Operation are located on drawings"*.

****

3.4.1 Scheduling

****

NOTE: FYI: Scheduling is normally performed by the Monitoring and Control (M&C) software (Section 25 10 10LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS)). The UMCS (Section 25 10 10) 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.

****

3.4.1.1 System Mode

AHUs shall operate in Occupied, Warm-Up-Cool-Down, or Unoccupied modes as specified. VAV boxes, Fan Coils, and other terminal equipment shall operate in Occupied or Unoccupied modes as specified. 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.

3.4.1.2 System Scheduler Requirements

****
NOTE: Indicate if a common schedule may be used for multiple Terminal Units (TUs). If allowing a common schedule for multiple TUs: keep the 'group of' bracketed text, and decide if TU groupings will be included on the drawings (keep the 'as shown' bracketed text) or if the Contractor should decide on groupings (remove the 'as shown' bracketed text).
****

The 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 dedicated to scheduling (performing no other control functionality) may contain multiple System Schedulers. A unique System Scheduler shall be provided for: each AHU including it's associated Terminal Units, and each stand-alone Terminal Unit (those not dependent upon AHU service)[or group of stand-alone Terminal Units acting according to a common schedule]. Each System Scheduler shall provide the following functionality:

3.4.1.2.1 Scheduled Occupancy Input

Accept network variable of type SNVT_occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_STANDBY, OC_OCCUPIED and OC_UNOCCUPIED.

3.4.1.2.2 Occupancy Override Input

Accept network variable of type SNVT_occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_STANDBY, OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL.

3.4.1.2.3 Space Occupancy Inputs

For systems with multiple occupancy sensors, accept multiple inputs of network variable type SNVT_Occupancy (as defined in the LonMark SNVT List). Input shall support the following possible values: OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL. For systems with a single occupancy sensor, accept a network variable input of type SNVT_Occupancy or a hardware binary input (BI) indicating the space occupancy status as Occupied or Unoccupied.

3.4.1.2.4 Air Handler Occupancy Output

For a System Scheduler for a system containing an air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Warm-Up-Cool-Down (when required by the AHU Sequence of Operation), Occupied and Unoccupied.

3.4.1.2.5 Terminal Unit Occupancy Output

For a System Scheduler for a stand-alone terminal unit, [a group of stand-alone terminal units acting according to a common schedule,] or a group of terminal units served by a single air handler, output one or more SNVTs indicating the desired occupancy status as one of the following possible values: Occupied and Unoccupied.

3.4.1.2.6 Default Schedule

****

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).

****

Incorporate a 24-hour 7-day default schedule as shown on the drawings which may be activated and deactivated by the System Scheduler Logic.

3.4.1.2.7 Communication Determination

Determine the time elapsed between receipts of the scheduled occupancy input SNVT, and use this elapsed time to activate and deactivate the Default Schedule as specified. (This provides the capability for the system scheduler to use its Default Schedule if it loses communication with the UMCS).

3.4.1.3 System Scheduler Output Determination

For controlling an Air Handler, a SNVT input of OC_STANDBY shall be interpreted as Warm-Up-Cool-Down if the sequence of operation supports that mode, otherwise OC_STANDBY shall be interpreted as Occupied. For Terminal Units, OC_STANDBY shall be interpreted as Occupied.

3.4.1.3.1 Air Handler Occupancy Output

If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, the Air Handler Occupancy Output shall be determined by the default schedule and the Space Occupancy Inputs. Otherwise, the output shall be determined as follows:

a. If the Override Occupancy Input is not OC_NUL, the Air Handler Occupancy Output shall determined from the Override Occupancy Input.

b. Otherwise, if at least the required number (as shown on the Occupancy Schedule Drawing) of Space Occupancy Inputs are OC_OCCUPIED or the hardware BI is Occupied the Air Handler Occupancy Output shall be OC_OCCUPIED.

c. Otherwise, the Air Handler Occupancy Output shall determined from the Scheduled Occupancy Input SNVT.

3.4.1.3.2 Terminal Unit Occupancy Output

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

a. If the Override Occupancy Input is not OC_NUL, the Terminal Unit Occupancy Output shall be determined from the Override Occupancy Input SNVT:

b. Otherwise, The Terminal Unit Occupancy Output shall determined from the Scheduled Occupancy SNVT.

3.4.1.4 Air Handler System Scheduling

a. The AHU Occupancy Output SNVT shall be bound from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Air Handler Sequence of Operation

b. For Air Handlers using occupancy sensors, the output SNVT (of type SNVT_Occupancy) of each occupancy sensor shall be bound to a Space Occupancy Input of the System Scheduler.

c. The Terminal Unit Occupancy Output SNVT shall be bound from the System Scheduler to each AHU-Dependent Terminal Unit.

d. AHU-Dependent Terminal Units with occupancy sensors shall have the Effective Occupancy SNVT (of type SNVT_Occupancy) of each Terminal Unit bound to a Space Occupancy Input of the System Scheduler.

3.4.1.5 Stand-Alone Terminal Unit Scheduling

The Terminal Unit Occupancy Output shall be bound from the System Scheduler to the DDC Hardware that executes the Occupancy Mode Determination part of the Terminal Unit Sequence of Operation.

3.4.2 Sequences of Operation for Air Handling Units

****

NOTE:

1) The following sequences, with few exceptions, assume the use of a System Scheduler and space occupancy input(s) to switch between occupied and unoccupied mode setpoints.

2) Show occupied and unoccupied mode setpoints on the Points Schedule. A configured setpoint is operator adjustable over the control network, but resides in the local DDC Hardware. In these sequences it serves as the default occupied mode setpoint and (at a separate setting/value) as an unoccupied mode 'setback' setpoint.

3) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the 'Thermostat and Occupancy Sensor Schedule'. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minute. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2.

4) Occupancy sensor location is left up to the Contractor. If ceiling mount sensors are preferred, edit the sequences and/or indicate in the Thermostat and Occupancy Sensor Schedule.

5) For each unit, as applicable, indicate if the zone temperature setpoint will be occupant adjustable by placing an 'X' in the 'Thermostat and Occupancy Sensor Schedule'. For non-occupant-adjustable setpoints, show the setpoint in the Points Schedule. The intent is that the Contractor provides one or the other as shown. Non-occupant-adjustable setpoints are adjustable by a system operator using a local display panel (LDP) or an operator workstation (and appropriate software).

****

3.4.2.1 All-Air Small Package Unitary System

****

NOTE: For heating-only or cooling-only systems, edit the sequence as required. Where applicable, select 'Emerg Heat' for heat pump systems.

****

Contractor shall install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.1.1 Fan ON-AUTO Switch

3.4.2.1.1.1 ON

With the thermostat fan ON-AUTO switch in the ON position, the DDC Hardware shall start the fan and it shall run continuously.

3.4.2.1.1.2 AUTO

With the thermostat fan ON-AUTO switch in the AUTO position, the DDC Hardware operates the fan according to HEAT-OFF-COOL[-EMERG HEAT] switch.

3.4.2.1.2 HEAT-OFF-COOL[-EMERG HEAT] Switch

3.4.2.1.2.1 HEAT-COOL[-EMERG HEAT]

With the thermostat switch in the HEAT or COOL [or EMERG HEAT] positions, the DDC Hardware shall operate the package unit according to the Occupancy Mode.

3.4.2.1.2.2 OFF

With the thermostat switch in the OFF position, the DDC Hardware shall de-energize the heating unit and cooling unit [and emergency supplemental heat].

3.4.2.1.3 Occupancy Modes

3.4.2.1.3.1 Occupied

The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

3.4.2.1.3.2 Unoccupied

The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

3.4.2.1.4 Safeties

The unit shall run subject to the unit manufacturer's safeties.

3.4.2.1.5 Zone Temperature Control

a. In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

b. In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP-UNOCC) shall be at the configured setpoint (ZN-T-SP-UNOCC) as shown.

c. The DDC Hardware shall cycle the fan, cooling unit, heating unit[, and emergency supplemental heat], in accordance with the HEAT-COOL[-EMERG HEAT] switch setting, to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP).

3.4.2.2 Heating and Ventilating Unit (or Unit Ventilator)

****

NOTE:

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

2) This system has a single outside air duct. Select either 2-position outside air dampers or modulating dampers.

3)Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from two different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

4) 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 Points Schedule as required.

5) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

6) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

7) Smoke control is not addressed in this Section. 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.2.1 HAND-OFF-AUTO Sswitches

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.2.1.1 HAND

With the H-O-A switch in HAND position, the supply fan starts and runs continuously, subject to Safeties.

3.4.2.2.1.2 OFF

With the H-O-A switch in OFF position, the supply fan stops.

3.4.2.2.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan runs subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

3.4.2.2.2 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes:

3.4.2.2.2.1 Occupied

The Unit's DDC Hardware shall be in the Occupied Mode when the input from the System Scheduler (SYS-OCC) is occupied [or when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied].

3.4.2.2.2.2 Unoccupied

The Unit's DDC Hardware shall be in the Unoccupied Mode when the input from the System Scheduler (SYS-OCC) is unoccupied [and when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied].

3.4.2.2.3 System Enable and Loop Enable

3.4.2.2.3.1 Occupied Mode

****

NOTE: Include bracketed text (Mixed Air Damper Control) for systems with 2-position dampers.

****

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Zone Temperature Control loop [and Mixed Air Damper Control]shall be enabled.

3.4.2.2.3.2 Unoccupied Mode

All control loops shall be disabled. When BLDG-T drops below BLDG-T-LL-SP (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Zone Temperature Control loop shall be enabled.

3.4.2.2.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.2.4.1 Proofs

Supply fan status (proof) (SF-S)

3.4.2.2.4.2 Safeties

a. Heating Coil discharge air temperature low limit (freeze stat) (HTG-DA-T-LL)

b. Supply air smoke (SA-SMK)

[c. Return air smoke (RA-SMK)]

3.4.2.2.4.3 DDC Hardware

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.2.5 Zone Temperature Control

****
NOTE: If the system has modulating dampers, select bracketed damper text in Zone Temperature Control paragraph. Otherwise, select Mixed Air Damper Control.
****

3.4.2.2.5.1 Enabled Loop

When this loop is enabled, the DDC Hardware shall modulate the heating valve [and outside air, relief, and return air dampers in sequence] to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP). [Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the outside air, relief, and return air dampers shall modulate to maintain zone temperature at setpoint. During occupied mode, outside air damper minimum position (OA-D-MIN) shall be as shown.] Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the heating valve shall modulate towards open to maintain zone temperature setpoint.

3.4.2.2.5.2 Disabled Loop

When this loop is disabled, the heating valve shall be closed [and the outside air damper and relief damper shall be closed and the return damper shall be open].

[3.4.2.2.6 Mixed Air Damper Control

When this is enabled, the outside air and relief air dampers shall be open and the return air damper shall be closed. When this is disabled, the outside air and relief air dampers shall be closed and the return air damper shall be open.

]3.4.2.3 Single Zone with Heating and [DX]Cooling Coils

****
NOTE:
1) Edit the sequence and drawings as necessary for

systems with/without a preheat coil, economizer, and other project specific control loop requirements.

2) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC, but don't use flow measurement in a constant volume system.

3) 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 Points Schedule and Control Schematic as required.

4) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from two different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

5) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

6) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

7) Smoke control is not addressed in this Section. 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until

the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.3.1 HAND-OFF-AUTO Switch

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.3.1.1 HAND

With the H-O-A switch in HAND position, the supply fan starts and runs continuously, subject to Safeties.

3.4.2.3.1.2 OFF

With the H-O-A switch in OFF position, the supply fan stops.

3.4.2.3.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan runs subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

3.4.2.3.2 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.3.3 System Enable and Loop Enable

3.4.2.3.3.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

3.4.2.3.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint(BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Heating Coil Temperature Control loop shall be enabled. The Outside Air Flow Control, Economizer Damper Control, and [DX] Cooling Coil Control loops shall be disabled.

[3.4.2.3.3.3 Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Minimum Outside Air Flow Control loop shall be disabled. All other control loops shall be enabled.

]3.4.2.3.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.3.4.1 Proofs

Supply fan status (proof) (SF-S)

3.4.2.3.4.2 Safeties

a. Heating coil discharge air temperature low limit (freeze stat) (HTG-DA-T-LL)

b. Supply air smoke (SA-SMK)

c. Return air smoke (RA-SMK)

3.4.2.3.4.3 DDC Hardware

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.3.5 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.3.6 Economizer Damper Control

3.4.2.3.6.1 Enabled Loop

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 (Economizer dampers) in sequence with the [DX] cooling coil control and heating coil control valve as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

3.4.2.3.6.2 Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.3.6.3 Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.3.7 Heating Coil Control

When this loop is enabled the DDC Hardware shall modulate the heating coil control valve in sequence with the [DX staging control][cooling coil valve] and economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled, the heating coil control valve shall be closed.

3.4.2.3.8 [DX] Cooling Coil Control

When this loop is enabled the DDC Hardware shall [stage the DX Unit] [modulate the cooling coil control valve] in sequence with the heating coil valve and economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled, the [DX unit shall be off] [cooling coil control valve shall be closed].

3.4.2.4 Single Zone with Dual-Temperature Coil

****

NOTE:
1) Edit the sequence and drawings as necessary for systems with/without a preheat coil, economizer, and other project specific control loop requirements.

2) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC, but don't use flow measurement in a constant volume system.

3) 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 Points Schedule and Control Schematic as required.

4) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from two different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

5) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff.

Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

6) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

7) Smoke control is not addressed in this Section. 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.
****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.4.1 HAND-OFF-AUTO Switch

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.4.1.1 HAND

With the H-O-A switch in HAND position, the supply fan starts and runs continuously, subject to Safeties.

3.4.2.4.1.2 OFF

With the H-O-A switch in OFF position, the supply fan stops.

3.4.2.4.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan runs subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

3.4.2.4.2 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.4.3 System Enable and Loop Enable

3.4.2.4.3.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

3.4.2.4.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the building low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Dual Temperature Coil Temperature Control loop shall be enabled. The Minimum Outside Air Flow Control, and Economizer Damper Control loops shall be disabled.

[3.4.2.4.3.3 Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops enabled.

]3.4.2.4.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.4.4.1 Proofs

Supply fan status (proof) (SF-S)

3.4.2.4.4.2 Safeties

a.) Dual Temperature coil discharge air temperature low limit (freeze stat) (DT-DA-T-LL)

b. Supply air smoke (SA-SMK)

c. Return air smoke (RA-SMK)

3.4.2.4.4.3 DDC Hardware

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.4.5   Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.4.6   Economizer Damper Control

3.4.2.4.6.1   Enabled Loop

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 (Economizer dampers) in sequence with the dual temperature coil to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

3.4.2.4.6.2   Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.4.6.3   Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.4.7   Dual Temperature Coil Control

3.4.2.4.7.1   Enabled Loop

When this loop is enabled, the DDC Hardware shall select heating or cooling mode based on a pipe-mounted dual-temperature supply water sensor. A single sensor may be used for multiple instances of this sequence.

3.4.2.4.7.2   DDC Hardware

The DDC Hardware shall modulate the coil control valve in sequence with the economizer dampers as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

3.4.2.4.7.3   Disabled Loop

When this loop is disabled, the control valve shall be closed.

3.4.2.5   Single Zone with Heating and Cooling Coils and Return Air Bypass

****

NOTE:
1) Edit the sequence and drawings as necessary for systems with/without a preheat coil, economizer, and other project specific control loop requirements.

2) Coordinate the enable/disable of the cooling coil 2-position valve with the chilled water source. If it is from a local chiller define and share the

enabling signal that turns on the chiller and opens the 2-position valve. Do not use a DX unit in place of the chilled water cooling coil.

3) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC, but don't use flow measurement in a constant volume system.

4) 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 Points Schedule and Control Schematic as required.

5) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from two different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

6) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

7) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

8) 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. With the present control sequence, in the event of shutdown due to smoke

detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.5.1 HAND-OFF-AUTO Switch

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.5.1.1 HAND

With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

3.4.2.5.1.2 OFF

With the H-O-A switch in OFF position, the supply fan shall stop.

3.4.2.5.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS) command and Safeties.

3.4.2.5.2 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.5.3 System Enable and Loop Enable

3.4.2.5.3.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

3.4.2.5.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and the Heating Coil Temperature Control loop shall be enabled. All other control loops shall be disabled.

[3.4.2.5.3.3 Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS).

The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

]3.4.2.5.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.5.4.1 Proofs

Supply fan status (proof) (SF-S)

3.4.2.5.4.2 Safeties

a. Heating coil discharge air temperature low limit (freezestat) (HTG-DA-T-LL)

b. Supply air smoke (SA-SMK)

c. Return air smoke (RA-SMK)

3.4.2.5.4.3 DDC Hardware

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.5.5 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.5.6 Economizer Damper Control

3.4.2.5.6.1 Enabled Loop

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, return air, and relief air dampers (Economizer dampers) in sequence with the bypass and supply dampers and the heating coil control valve as shown to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown.

3.4.2.5.6.2 Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.5.6.3 Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.5.7 Temperature Control Loop Heating Coil Control

When this loop is enabled the DDC Hardware shall modulate the heating coil control valve, modulate the economizer dampers if enabled, open and close the 2-position cooling coil valve and modulate the bypass and supply air dampers in sequence to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. When this loop is disabled both valves shall be closed and the bypass and supply air dampers shall be positioned to bypass air.

3.4.2.6 Single Zone with Humidity Control

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NOTE:
1) Edit the sequence and drawings as necessary for systems with/without a preheat coil and other project specific control loop requirements.

2) 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 Points Schedule and Control Schematic as required.

3) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from 2 different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

3) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

4) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a

separate DDC reset, as described above, is also used.

5) 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.
****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.6.1 HAND-OFF-AUTO Switch

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.6.1.1 HAND

With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

3.4.2.6.1.2 OFF

With the H-O-A switch in OFF position, the supply fan shall stop.

3.4.2.6.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

3.4.2.6.2 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.6.3 System Enable and Loop Enable

3.4.2.6.3.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS) and all control loops shall be enabled.

3.4.2.6.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Preheat Coil Control loop and Reheat Coil Control loop shall be enabled and all other loops shall be disabled.

[3.4.2.6.3.3 Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

]3.4.2.6.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.6.4.1 Proofs

Supply fan status (proof) (SF-S)

3.4.2.6.4.2 Safeties

a. Preheat coil discharge air temperature low limit (freezestat) (PH-DA-T-LL)

b. Supply air smoke (SA-SMK)

c. Return air smoke (RA-SMK)

3.4.2.6.4.3 DDC Hardware

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.6.5 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.6.6   Preheat Coil Control Loop

When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat coil discharge air temperature (PH-DA-T) at setpoint (PH-DA-T-SP) as shown. When this loop is disabled, the preheat coil valve shall be closed.

3.4.2.6.7   Cooling-and-Dehumidification Coil Control

When this loop is enabled the DDC Hardware shall modulate the cooling and dehumidification valve to maintain either the zone temperature (ZN-T) at setpoint (ZN-T-SP) or zone relative humidity (ZN-RH) at setpoint (ZN-RH-SP), whichever calls for more chilled water flow. The valve shall be modulated in sequence with the reheat valve and humidification valve as shown to avoid simultaneous cooling and reheating, and simultaneous dehumidification and humidification. When this loop is disabled, the coil valve shall be closed.

3.4.2.6.8   Reheat Coil Control

When this loop is enabled the DDC Hardware shall modulate the reheat coil valve to maintain the zone temperature (ZN-T) at setpoint (ZN-T-SP) as shown. The valve shall be modulated in sequence with the cooling-and-dehumidification valve as shown to avoid simultaneous cooling and reheating. When this loop is disabled, the coil valve shall be closed.

3.4.2.6.9   Humidification Control

When this loop is enabled the DDC Hardware shall modulate the humidifier valve to maintain zone relative humidity (ZN-RH) at setpoint (ZN-RH-SP). The valve shall be modulated in sequence with the cooling-and-dehumidification valve as shown to avoid simultaneous dehumidification and humidification. When the supply air duct humidity (SA-RH) rises above 80 percent relative humidity, the humidifier valve shall begin to modulate towards closed and shall continue to gradually move towards closed until the supply air duct humidity reaches 90 percent relative humidity, at which point the humidifier valve shall be fully closed. When this loop is disabled, the humidifier valve shall be closed.

3.4.2.7   Multizone [Dual-Duct] [with][without] Return Fan

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NOTE:

1) The sequence is identical for a Dual-Duct system. You need only change hot/cold deck to hot/cold duct.

2) Edit the sequence and drawings as necessary for systems with/without a return fan, preheat coil, economizer, and other project specific control loop requirements.

3) Choose whether or not to require setpoint reset of the hot deck temperature setpoint, and whether the reset should be based on Outside Air Temperature or Coldest Zone Temperature. Edit the control schematic drawing to show the reset parameters.

4) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC, but don't use flow measurement in a constant volume system.

5) 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 Points Schedule and Control Schematic as required.

6) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from 2 different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

7) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

8) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

9) 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any

DDC input to force the fan(s) to run.
****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.7.1 HAND-OFF-AUTO switches and Fire Alarm Panel (FAP) Signal:

Supply Fan VFD. Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.7.1.1 HAND

With the H-O-A switch in HAND position, the supply fan starts and runs continuously, subject to Safeties.

3.4.2.7.1.2 OFF

With the H-O-A switch in OFF position, the supply fan stops.

3.4.2.7.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan runs subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

[3.4.2.7.2 Return Fan VFD

The return fan shall incorporate an integral H-O-A switch, manual speed adjustment and also accept a Fire Alarm Panel (FAP) signal. The return fan shall run according to the following inputs (in order of decreasing priority):

a. FAP signal shall cause the RF to run at 100 percent

b. SF-S (proof) shall be connected to the RF VFD safety circuit such that if SF is not running, RF shall be off.

c. RF H-O-A switch shall select RF mode as follows:

(1) When switch is in Hand, fan shall run. Fan speed shall be under manual control.

(2)When switch is in Off, fan shall be off.

(3) When switch is in Auto, fan shall run. Fan speed shall be under control of the DDC Hardware.

]3.4.2.7.3 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.7.4   System Enable and Loop Enable

3.4.2.7.4.1   Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

3.4.2.7.4.2   Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Hot Deck Coil Control loop and all Zone Temperature Control loops shall be enabled, and all other control loops shall be disabled.

[3.4.2.7.4.3   Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

]3.4.2.7.5   Proofs and Safeties

The supply fan and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.7.5.1   Proofs

a.) Supply fan status (proof) (SF-S)[

b. Return fan status (proof) (RF-S)]

3.4.2.7.5.2   Safeties

a. Mixed air temperature low limit (freeze stat) (MA-T-LL)[

b. Supply air smoke (SA-SMK)][

c. Return air smoke (RA-SMK)]

3.4.2.7.5.3   DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.7.6   Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.7.7 Mixed Air Temperature Control With Economizer

3.4.2.7.7.1 Enabled Loop

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 (MA-T) at setpoint (MA-T-SP) as shown.

3.4.2.7.7.2 Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.7.7.3 Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.7.8 Hot Deck Coil Control

3.4.2.7.8.1 Enabled Loop

When this loop is enabled the DDC Hardware shall modulate the hot deck heating coil valve to maintain the hot deck temperature (HD-T) at setpoint (HD-T-SP) as shown. When this loop is disabled, the hot deck coil valve shall be closed.

[3.4.2.7.8.2 DDC Hardware Reset

The DDC Hardware shall reset the hot deck temperature setpoint (HD-T-SP) using a linear reset schedule as shown. Reset of the setpoint (HD-T-SP) shall be based on [Outside Air Temperature] [Coldest Zone Temperature].

]3.4.2.7.9 Cold Deck Coil Control

When this loop is enabled the DDC Hardware shall modulate the cold deck cooling coil valve to maintain the cold deck temperature (CD-T) at setpoint (CD-T-SP) as shown. When this loop is disabled, the cold deck cooling coil valve shall be closed.

3.4.2.7.10 Zone Temperature Control

When this loop is enabled:

3.4.2.7.10.1 Zone Temperature Setpoint

The zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.4.2.7.10.2   DDC Hardware Modulation

The DDC Hardware shall modulate the hot deck and cold deck dampers to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP).

3.4.2.8   Multizone with Hot Deck Bypass [with][without] Return Fan

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NOTE:

1) NOTE: Edit the sequence and drawings as necessary for systems with/without a return fan, preheat coil, economizer, and other project specific control loop requirements.

2) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC, but don't use flow measurement in a constant volume system.

3) 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 Points Schedule and Control Schematic as required.

4) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from 2 different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

5) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

6) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a separate DDC reset, as described above, is also used.

7) 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.8.1 HAND-OFF-AUTO Switches

Supply fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and shall start the fan. The fan motor starter shall accept an occupant accessible emergency shutoff switch as shown. The supply fan motor starter shall have an H-O-A switch:

3.4.2.8.1.1 HAND

With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties.

3.4.2.8.1.2 OFF

With the H-O-A switch in OFF position, the supply fan shall stop.

3.4.2.8.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop (SF-SS)command and Safeties.

[3.4.2.8.2 Return Fan Motor Starter

Return fan motor starter shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches shall start the fan. The return fan motor starter shall have an H-O-A switch:

3.4.2.8.2.1 HAND

With the H-O-A switch in HAND position, the return fan shall run subject to Safeties.

3.4.2.8.2.2 OFF

With the H-O-A switch in OFF position, the return fan shall be off.

3.4.2.8.2.3 AUTO

With the H-O-A switch in AUTO position, the return fan shall run subject to the supply fan running.

]3.4.2.8.3 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.4.2.8.4 System Enable and Loop Enable

3.4.2.8.4.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

3.4.2.8.4.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), and all Zone Temperature Control loops shall be enabled. The Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, and Cold Deck Coil Control loops shall be disabled.

[3.4.2.8.4.3 Warm Up / Cool Down Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled. The Zone Temperature Control loops serviced by the AHU shall also be enabled.

]3.4.2.8.5 Proofs and Safeties

The supply fan[, return fan,] and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the fan starter circuit as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.8.5.1 Proofs

a. Supply fan status (proof) (SF-S)

[b. Return fan status (proof) (RF-S)]

3.4.2.8.5.2 Safeties

a. Mixed air temperature low limit (freeze stat) (MA-T-LL)

b. Supply air smoke (SA-SMK)

[c. Return air smoke (RA-SMK)]

3.4.2.8.5.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.8.6 Minimum Outside Air Flow Control

When this loop is enabled the DDC Hardware shall open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.8.7 Mixed Air Temperature Control With Economizer

3.4.2.8.7.1 Enabled Loop

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 (MA-T) at setpoint (MA-T-SP) as shown.

3.4.2.8.7.2 Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.8.7.3 Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.8.8 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 (SA-T) at setpoint (SA-T-SP) as shown. When this loop is disabled, the cooling coil valve shall be closed.

3.4.2.8.9 Zone Temperature Control

a. The zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

b. The DDC Hardware shall modulate the zone bypass and cold deck dampers, and the zone heating coil valve to maintain zone temperature (ZN-T) at setpoint (ZN-T-SP). Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint, subject to the zone temperature setpoint deadband as shown, the zone cold deck damper shall modulate towards open as the bypass deck damper modulates towards closed. Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the bypass damper shall be full open and the zone heating valve shall modulate towards open.

c. Systems with electric resistance heating elements shall require proof of air flow before activating the heating elements.

3.4.2.9 Variable Air Volume System [with][without] Return Fan

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NOTE:
1) Edit the sequence and drawings as necessary for systems with/without a return fan, preheat coil, economizer, and other project specific control loop requirements.

2) Minimum outside air flow control can be accomplished several different ways. Refer to the UFC.

3) 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 Points Schedule and Control Schematic as required.

4) This spec does not include a variable frequency drive (VFD) specification. 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 circuit and Fire Alarm Panel (FAP) override switch.

5) Indicate the System Scheduler and M&C Software Occupancy Schedule on the Occupancy Schedule drawing. The designer needs to coordinate System Scheduler (occupancy mode determination) with space occupancy sensor input and pushbutton override switch input use. As described in the System Scheduler sequence, 'occupied' inputs from 2 different spaces are required to help avoid needless turning on of the system (due to cleaning staff or security staff passing through after hours).

6) Absence of fan proof(s) or activation of any safety will result in system shutdown. The system remains shutdown until manually reset devices are reset and a manual reset button (RST-BUT), local to the DDC controller, is pressed. Reset could also be performed from a workstation (via SNVT) or local display panel (LDP). It is recommended that you coordinate the decision with the local O&M staff. Edit the Control Logic Diagram and Points Schedule to indicate which reset method is to to be provided by the Contractor.

7) The hardware (product) specification requires that the low limit (freezestat) device include a manual reset at the device. In the event of shutdown due to freeze stat trip the system will remain shutdown until the device is reset and a

separate DDC reset, as described above, is also used.

8) 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. With the present control sequence, in the event of shutdown due to smoke detector input the system will remain shutdown until the smoke detector is reset and a separate DDC reset, as described above, is also used. The Fire Alarm Panel (FAP) input takes precedence over any DDC input to force the fan(s) to run.

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Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.2.9.1 HAND-OFF-AUTO Switches

Supply fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100 percent speed. The VFD shall accept an occupant accessible emergency shutoff switch as shown. The supply fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.4.2.9.1.1 HAND

With the H-O-A switch in HAND position, the supply fan shall start and run continuously, subject to Safeties. Fan speed shall be under manual-operator control.

3.4.2.9.1.2 OFF

With the H-O-A switch in OFF position, the supply fan shall stop.

3.4.2.9.1.3 AUTO

With the H-O-A switch in AUTO position, the supply fan shall run subject to the Supply Fan Start/Stop Signal (SF-SS) and Safeties. Fan speed shall be under control of the DDC Hardware.

[3.4.2.9.2 Return Fan Variable Frequency Drive

Return fan variable frequency drive (VFD) unit shall accept a Fire Alarm Panel (FAP) signal that takes precedence over all other VFD inputs and switches and shall cause the VFD to run at 100 percent speed. The return fan variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.4.2.9.2.1 HAND

With the H-O-A switch in HAND position, the return fan shall run subject to Safeties. Fan speed shall be under manual-operator control.

3.4.2.9.2.2 OFF

With the H-O-A switch in OFF position, the return fan shall be off.

3.4.2.9.2.3 AUTO

With the H-O-A switch in AUTO position, the return fan shall run subject to the supply fan running. Fan speed shall be under control of the DDC Hardware.

]3.4.2.9.3 Occupancy Modes

The system shall obtain its Occupancy Mode input from the System Scheduler as specified and shown. The system shall operate in one of the following modes: Occupied, Unoccupied[, or Warm Up/Cool Down].

3.4.2.9.4 Proofs and Safeties

The supply fan[, return fan,] and all DDC Hardware control loops shall be subject to Proofs and Safeties. Safeties shall be direct-hardwire interlocked to the VFD as shown. DDC Hardware shall monitor all proofs and safeties and failure of any proof or activation of any safety shall result in all control loops being disabled and the AHU fan being commanded off until reset.

3.4.2.9.4.1 Proofs

a. Supply fan status (SF-S)

[b. Return fan status (RF-S)]

3.4.2.9.4.2 Safeties

a. Preheat coil discharge air temperature low limit (freezestat) (PH-DA-T-LL) for systems with a preheat coil. Cooling coil discharge air temperature low limit (freezestat) (CLG-DA-T-LL) for all other systems

b. Supply air duct pressure high limit (SA-P-HL)

c. Supply air smoke (SA-SMK)

d. Return air smoke (RA-SMK)

3.4.2.9.4.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.2.9.5 System Enable and Loop Enable

3.4.2.9.5.1 Occupied Mode

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). All control loops shall be enabled.

3.4.2.9.5.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) all control loops shall be disabled and the supply fan shall not run. When BLDG-T drops below BLDG-T-LL (with a 3 degrees C 5 degrees F deadband) the supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS), the Supply Duct Static Pressure Control[, Return Fan Volume Control][, Preheat Control] loops shall be enabled. The Minimum Outside Air Flow Control, Mixed Air Temperature Control, and Cooling Coil Control loops shall be disabled.

[3.4.2.9.5.3 Warm Up/Cool Down

The supply fan shall be enabled (SYS-ENA) and commanded to run (SF-SS). The Minimum Outside Air Flow Control loop shall be disabled and all other control loops shall be enabled.

]3.4.2.9.6 Fan Capacity Control

3.4.2.9.6.1 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 (SA-P) at setpoint (SA-P-SP) as shown, as measured by the duct static pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

[3.4.2.9.6.2 Return Fan Volume Control

When this loop is enabled the DDC Hardware shall modulate the return fan variable frequency drive unit to maintain a constant volumetric airflow difference at setpoint (F-DIFF-SP) 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 shall be zero percent.

]3.4.2.9.7 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 (MINOA-F) at setpoint (MINOA-F-SP) as shown. When this loop is disabled, the minimum outside air damper shall be closed.

3.4.2.9.8 Mixed Air Temperature Control With Economizer

3.4.2.9.8.1 Enabled Loop

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 (MA-T) at setpoint (MA-T-SP) as shown.

3.4.2.9.8.2   Disabled Loop

When this loop is disabled, or the Economizer is OFF as determined by the Economizer Enable Logic, the economizer outside air and relief air dampers shall be closed, and the return air damper shall be open.

3.4.2.9.8.3   Economizer Enable Logic

The economizer shall be ON when the outside air dry bulb temperature is between the high limit (ECO-HL-SP) and low limit (ECO-LL-SP) setpoints as shown. The Economizer shall otherwise be OFF. ECO-HL-SP and ECO-LL-SP shall each have a 1 degree C 2 degrees F deadband.

3.4.2.9.9   Cooling Coil Control

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

[3.4.2.9.10   Preheat Coil Control

When this loop is enabled the DDC Hardware shall modulate the preheat coil valve to maintain the preheat coil discharge air temperature (PH-DA-T) at setpoint (PH-DA-T-SP) as shown. When this loop is disabled, the preheat coil valve shall be closed.

]3.4.3   Sequences of Operation for Terminal Units

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NOTE: For the VAV Box Sequences:
1) Show the occupancy schedule (days/times) on the Occupancy Schedule drawing. For simplicity, it is recommended that all boxes, served by a common air handler, operate on the same schedule.

2) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the 'Thermostat and Occupancy Sensor Schedule'. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minutes. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2

3) For each VAV box thermostat, indicate if the zone temperature setpoint will be occupant adjustable by placing an 'X' in the 'Thermostat and Occupancy Sensor Schedule'. For non-occupant-adjustable setpoints, show the setpoint in the Points Schedule. The intent is that the Contractor provides one or the other as shown.
Non-occupant-adjustable setpoints are adjustable by a system operator using a local display panel (LDP) or operator workstation (and appropriate software).

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3.4.3.1   Zone Temperature Control - Cooling-Only VAV Box

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.1.1   Occupancy Modes

3.4.3.1.1.1   Occupied

The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

3.4.3.1.1.2   Unoccupied

The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

Safeties

This system has no safeties.

3.4.3.1.2   Zone Temperature Control

3.4.3.1.2.1   Occupied Mode

In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown. The DDC Hardware shall modulate the VAV box damper to maintain VAV box supply air flow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Sequencing shall be as shown: Upon a rise in zone temperature (ZN-T) above zone setpoint (ZN-T-SP), 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 temperature and zone temperature setpoint as shown.

3.4.3.1.2.2   Unoccupied Mode

In the Unoccupied Mode the VAV box damper shall be at its minimum position.

3.4.3.2   Zone Temperature Control - VAV Box with Reheat

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.2.1   Occupancy Modes

3.4.3.2.1.1   Occupied

The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

3.4.3.2.1.2 Unoccupied

The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

3.4.3.2.2 Safeties

VAV boxes with electric resistance heating elements shall require proof of air flow before activating the heating elements.

3.4.3.2.3 Zone Temperature Control

a. In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

b. In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint as shown.

c. The DDC Hardware shall modulate the VAV box damper to maintain VAV box supply air flow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box. Sequencing shall be as shown: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), 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 temperature and zone temperature setpoint as shown. Upon a fall in zone temperature below zone temperature 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.

3.4.3.3 Zone Temperature Control - Fan Powered VAV Box

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NOTE: This sequence is applicable to both Series and Parallel fan powered VAV boxes.

As specified in Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM, fans located in series fan-powered VAV boxes must start whenever the AHU fan that serves these boxes is started.

Select appropriate fan control text for series or parallel application. Note that since an unoccupied AHU cannot run except to provide heating, unoccupied zone temperature setpoint deadband should be large enough to prevent an unoccupied VAV from attempting to provide cooling.

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Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.3.1 Occupancy Modes

3.4.3.3.1.1 Occupied

The VAV box DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is occupied or when the input from the System Scheduler (SYS-OCC) is occupied.

3.4.3.3.1.2 Unoccupied

The VAV box DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) (ZN-OCC) indicate that the space is unoccupied and the input from the System Scheduler (SYS-OCC) is unoccupied.

3.4.3.3.2 Safeties

VAV boxes with electric resistance heating elements shall require proof of air flow before activating the heating elements.

3.4.3.3.3 Fan Control

[Series fans shall run whenever the box is occupied or the Zone Temperature Control loop determines that the box is in heating mode. Prior to starting the fan, the supply damper shall close. The controller shall pause after closing the damper before starting the fan to ensure that the fan is not spinning due to supply air delivered by the AHU. After the fan starts, the supply damper shall be controlled by the Zone Temperature Control loop.][Parallel fans shall run whenever the Zone Temperature Control loop determines that the box is in heating mode.]

3.4.3.3.4 Zone Temperature Control

3.4.3.3.4.1 Occupied Mode

In the Occupied Mode the zone temperature setpoint (ZN-T-SP) shall be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.4.3.3.4.2 Unoccupied Mode

In the Unoccupied Mode the zone temperature setpoint (ZN-T-SP)shall be at the configured setpoint as shown.

3.4.3.3.4.3 Sequencing

a. Cooling Mode: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, the airflow setpoint shall be adjusted between minimum and maximum based on the difference between zone temperature and zone temperature setpoint as shown. The DDC Hardware shall modulate the VAV box damper to mix supply and plenum return air as it maintains VAV box supply airflow (VAV-SA-F) at setpoint as measured by a multi-point flow sensing element at the inlet to the VAV box.

b. Heating Mode: Upon a fall in zone temperature below zone temperature setpoint, subject to the deadband as shown, the DDC Hardware shall[first turn on the parallel fan and then] modulate the VAV box damper to mix supply and plenum return air to maintain 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.

3.4.3.4 Perimeter Radiation Control Sequence

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NOTE:
1) Show the occupancy schedule (days/times) on the Occupancy Schedule drawing. For simplicity, it is recommended that all units operate on the same schedule.

2) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the Thermostat Schedule. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minutes. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2
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Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.4.1 Occupancy Modes

3.4.3.4.1.1 Occupied

The radiator DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

3.4.3.4.1.2 Unoccupied

The radiator DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

3.4.3.4.2 Safeties

This system has no safeties.

3.4.3.4.3 Space Temperature Control

3.4.3.4.3.1 Occupieed Mode

In the Occupied Mode the DDC Hardware shall modulate the heating control valve to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.4.3.4.3.2 Unoccupied Mode

In the Unoccupied Mode the DDC Hardware shall modulate the heating control valve to maintain space temperature at the configured setpoint as shown.

3.4.3.5   Unit Heater and Cabinet Unit Heater

****
NOTE:
1) Show the occupancy schedule (days/times) on the Occupancy Schedule drawing. For simplicity, it is recommended that all units operate on the same schedule.

2) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the Thermostat Schedule. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minute. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2
****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.5.1   Off-Auto Switch

3.4.3.5.1.1   OFF

With the thermostat OFF-AUTO switch in the OFF position, the DDC Hardware shall stop the fan and close the heating control valve.

3.4.3.5.1.2   AUTO

With the thermostat OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the unit in accordance with its Occupancy Mode.

3.4.3.5.2   Occupancy Modes

3.4.3.5.2.1   Occupied

The unit heater DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

3.4.3.5.2.2   Unoccupied

The unit heater DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

3.4.3.5.3   Safeties

The unit shall run subject to the unit manufacturer's safeties.

3.4.3.5.4   Space Temperature Control

3.4.3.5.4.1   Occupied Mode

In the Occupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.4.3.5.4.2   Unoccupied Mode

In the Unoccupied Mode the DDC Hardware shall modulate the heating control valve and cycle the multi-speed fan to maintain space temperature at the configured setpoint as shown.

3.4.3.6   Gas-Fired Infrared Heater

****

NOTE:
1) Use of a System Scheduler is likely not needed in this application. If it is, edit the sequence and the drawings.

2) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the Thermostat Schedule. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minute. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.6.1   On-Off-Auto Switch

3.4.3.6.1.1   ON

With the thermostat ON-OFF-AUTO switch in the ON position, the DDC Hardware shall energize the heater and the heater shall run continuously.

3.4.3.6.1.2   OFF

With the thermostat ON-OFF-AUTO switch in the OFF position, the DDC Hardware shall de-energize the heater.

3.4.3.6.1.3   AUTO

With the thermostat ON-OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the heater in accordance with its Occupancy Mode.

3.4.3.6.2   Occupancy Modes

3.4.3.6.2.1   Occupied

The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied.

3.4.3.6.2.2   Unoccupied

The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied.

3.4.3.6.3   Safeties

The heater shall run subject to the unit manufacturer's safeties.

3.4.3.6.4   Space Temperature Control

3.4.3.6.4.1   Occupied Mode

In the Occupied Mode the DDC Hardware shall operate the heater to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown.

3.4.3.6.4.2   Unoccupied Mode

In the Unoccupied Mode the DDC Hardware shall operate the heater to maintain space setpoint at the configured unoccupied setpoint as shown.

3.4.3.7   Dual Temperature Fan-Coil Unit

****

NOTE:
1) Show the occupancy schedule (days/times) on the Occupancy Schedule drawing. For simplicity, it is recommended that all units operate on the same schedule.

2) Space occupancy input(s) may consist of an occupancy sensor and/or a local push-button. Indicate the use of a sensor and/or push-button by placing an 'X' in the Thermostat Schedule. If a push-button is used, show the override time duration in the Schedule. Note that the occupancy sensor specification requires a delay that is adjustable between 30 seconds and 15 minute. If a delay outside of this range is needed edit the Occupancy Sensor Product specification in PART 2

3) Show 2-way and 3-way valve selections on the Valve Schedule.

4) Fan coil units typically have unit-mounted thermostats. Indicate if wall mounting is desired and/or show in the Thermostat Schedule for the individual fan coil units.

****

Install DDC hardware to perform this Sequence of Operation and to provide

SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.3.7.1   Off-Auto Switch

3.4.3.7.1.1   OFF

With the thermostat OFF-AUTO switch in the OFF position, the DDC Hardware shall stop the fan and close the dual-temperature control valve.

3.4.3.7.1.2   AUTO

With the thermostat OFF-AUTO switch in the AUTO position, the DDC Hardware shall control the unit in accordance with its Occupancy Mode.

3.4.3.7.2   Occupancy Modes

3.4.3.7.2.1   Occupied

The unit DDC Hardware shall be in the Occupied Mode when the local space occupancy input(s) indicate that the space is occupied or when the input from the System Scheduler is occupied.

3.4.3.7.2.2   Unoccupied

The unit DDC Hardware shall be in the Unoccupied Mode when the local space occupancy input(s) indicate that the space is unoccupied and when the input from the System Scheduler is unoccupied.

3.4.3.7.3   Heat/Cool Modes

The DDC Hardware shall automatically switch the fan coil unit DDC Hardware between the heating and cooling modes and the resultant control action, based on a pipe-mounted dual-temperature supply water temperature sensor.

3.4.3.7.4   Safeties

The unit shall run subject to the unit manufacturer's safeties.

3.4.3.7.5   Space Temperature Control

3.4.3.7.5.1   Occupied Mode

In the Occupied Mode the DDC Hardware shall modulate the dual-temperature control valve and modulate the multi-speed fan to maintain space temperature at the configured setpoint or at the occupant-adjustable setpoint via the [wall-mounted] thermostat, as shown.

3.4.3.7.5.2   Unoccupied Mode

In the Unoccupied Mode the DDC Hardware shall modulate the dual-temperature control valve and modulate the multi-speed fan to maintain space temperature at the configured setpoint as shown.

3.4.4 Sequences of Operation for Hydronic Systems

3.4.4.1 Hydronic Heating Hot Water from Distributed [Steam][HTHW] Converter

****

NOTE:
1) Select Steam or High Temperature Hot Water as required.

2) The designer may want to consider other conditions under which this system is enabled, such as outside air temperature.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.4.1.1 System Enable and Loop Enable

a. This system shall monitor the enabled status of all systems served by this system. [If [one][two][___] or more systems served by this system are enabled, this system shall be enabled (SYS-ENA), otherwise this system shall be disabled][___].

b. When this system is enabled (SYS-ENA) the hot water pump shall be commanded on via the Hot Water Pump Start/Stop (HW-PMP-SS) command.

c. When this system is enabled (SYS-ENA) and the hot water pump is proofed on, the Heat Exchanger Control loop shall be enabled.

3.4.4.1.2 HAND-OFF-AUTO Switch

The hot water pump motor starter shall have an H-O-A switch:

3.4.4.1.2.1 HAND

With the H-O-A switch in HAND position, the pump starts and runs continuously.

3.4.4.1.2.2 OFF

With the H-O-A switch in OFF position, the pump stops.

3.4.4.1.2.3 AUTO

With the H-O-A switch in AUTO position, the pump runs subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command.

3.4.4.1.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.1.3.1 Proofs

Hot water pump status (HW-PMP-S)

3.4.4.1.3.2 Safeties

None

3.4.4.1.3.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.4.1.4 Heat Exchanger Valve Control

****

NOTE: If a reset schedule is not required delete this option ([determined from a linear reset schedule]) from the sequence along with the reset schedule in the drawing. Where reset is used, edit the temperatures shown in the reset schedule on the drawing.

****

When this loop is enabled DDC Hardware shall modulate the [steam][high temperature hot water] valve to maintain the Hot Water Supply Temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HW-T-SP) shall be [determined from a linear reset schedule] as shown. When this loop is disabled, the valve shall be closed.

3.4.4.2 Hydronic Heating Hot Water From Single-Building Boiler

****

NOTE: The designer may want to consider other conditions under which this system is enabled, such as outside air temperature.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.4.2.1 System Enable and Loop Enable

a. This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If no systems served by this system are enabled, this system shall be disabled.

b. When this system is enabled (SYS-ENA) and the hot water pump is proofed on, the boiler control and hot water temperature control loops shall be enabled.

3.4.4.2.2 HAND-OFF-AUTO Switch

The hot water pump motor starter shall have an H-O-A switch:

3.4.4.2.2.1 HAND

With the H-O-A switch in HAND position, the pump shall start and run continuously.

3.4.4.2.2.2 OFF

With the H-O-A switch in OFF position, the pump shall stop.

3.4.4.2.2.3 AUTO

With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command.

3.4.4.2.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.2.3.1 Proofs

Hot water pump

3.4.4.2.3.2 Safeties

None

3.4.4.2.3.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.4.2.4 Boiler Control

When this loop is enabled, the DDC Hardware shall turn the boiler on. When this loop is disabled, the boiler shall be off.

3.4.4.2.5 Hot Water Temperature Control

When this loop is enabled the DDC Hardware shall modulate the 3-way mixing valve to maintain hot water supply temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HWS-T-SP) shall be [determined from a linear reset schedule] as shown. When this loop is disabled, the valve shall be in its normal (failsafe) position.

3.4.4.3 Hydronic Dual-Temperature System with [Steam][High Temperature Hot Water] Heat Exchanger and Chilled Water

****

NOTE:
1) Select Steam or High Temperature Hot Water as required.

3) The designer may want to consider other conditions under which this system is enabled, such as outside air temperature.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule. Unless otherwise specified, all modulating control shall be proportional-integral (PI) control.

3.4.4.3.1 System Enable and Loop Enable

a. This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If all systems served by this system are not enabled, this system shall not be enabled.

b. When the system is enabled (SYS-ENA) the pump shall run.

c. When this system is enabled (SYS-ENA), and the HEATING/COOLING switch is in HEATING the Heat Exchanger Control loop shall be enabled.

****

NOTE: Chiller Enable (the following paragraph) is only required when there is a local chiller. In cases where chilled water is from a central plant delete the chiller enable requirement.

****

[d. When this system is enabled (SYS-ENA), and the HEATING/COOLING switch is in COOLING and the dual-temperature return water (DTWR-T) is below the dual-temperature return water high-limit temperature (DTWR-T-HL) setpoint of 29 degrees C 85 degrees F, the chiller shall be enabled.]

3.4.4.3.2 Switchover Valve Operation

The DDC Hardware shall monitor the status of the DTWR-T-LL and DTWR-T-HL switches.

3.4.4.3.2.1 HEATING/COOLING Switch in the HEATING Position

With the HEATING/COOLING switch in the HEATING position, the switchover valve shall open the heat-cool system piping to the heat exchanger and close the heat-cool system piping to the [central plant chilled water][single-building chiller].

3.4.4.3.2.2 HEATING/COOLING Switch in the COOLING Position

With the HEATING/COOLING switch in the COOLING position, the switchover valve shall open the heat-cool system piping to the [central plant chilled water][single-building chiller] and close the heat-cool system piping to the heat exchanger whenever the dual-temperature return water temperature (DTWR-T) is below the dual-temperature return water high-limit temperature (DTWR-T-HL).

3.4.4.3.3 HAND-OFF-AUTO Switch

The Dual-Temperature water pump motor starter shall have an H-O-A switch:

3.4.4.3.3.1 HAND

With the H-O-A switch in HAND position, the pump starts and runs continuously.

3.4.4.3.3.2 OFF

With the H-O-A switch in OFF position, the pump stops.

3.4.4.3.3.3 AUTO

With the H-O-A switch in AUTO position, the pump runs subject to the Dual-Temperature Water Pump Start/Stop (DTW-PMP-SS) System Enable (SYS-ENA) command.

3.4.4.3.4 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.3.4.1 Proofs

None

3.4.4.3.4.2 Safeties

Heat exchanger differential pressure switch (HX-P-LL) shall be direct-hardwire interlocked to the [steam][high temperature hot water] valve.

3.4.4.3.4.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

[3.4.4.3.5 [Heat Exchanger][Mixing] Valve Control

When this loop is enabled the DDC Hardware shall modulate the [steam][high temperature hot water] valve to maintain the Hot Water Supply Temperature (HWS-T) at setpoint (HWS-T-SP). The Hot Water Supply Temperature Setpoint (HWS-T-SP) shall be [determined from a linear reset schedule] as shown. The DDC Hardware shall monitor the status of the HX-P-LL safety. When this loop is disabled, the valve shall be closed.

]3.4.4.4 Hydronic Secondary with Variable Speed Pump

****

NOTE:
1) This spec does not include a variable frequency drive (VFD) specification. Specify a VFD that meets the requirements of the control sequence including the integral H-O-A.

2) The designer may want to consider other conditions under which this system is enabled, such as outside air temperature.

****

Install DDC hardware to perform this Sequence of Operation and to provide SNVT inputs and outputs as specified and shown on the Points Schedule.

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

3.4.4.4.1 System Enable and Loop Enable:

a. This system shall monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, this system shall be enabled (SYS-ENA). If all systems served by this system are not enabled, this system shall not be enabled.

b. When this system is enabled (SYS-ENA) the Pressure Control loop shall be enabled.

3.4.4.4.2 HAND-OFF-AUTO Switch

The hot water pump variable frequency drive (VFD) unit shall have an integral H-O-A switch:

3.4.4.4.2.1 HAND

With the H-O-A switch in HAND position, the pump starts and runs continuously. Pump speed shall be under manual-operator control.

3.4.4.4.2.2 OFF

With the H-O-A switch in OFF position, the pump stops.

3.4.4.4.2.3 AUTO

With the H-O-A switch in AUTO position, the pump shall run subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command and pump speed shall be under control of the DDC system.

3.4.4.4.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.4.3.1 Proofs

None

3.4.4.4.3.2 Safeties

None

3.4.4.4.3.3 DDC Hardware Reset

DDC Hardware reset of all proofs and safeties shall be via a local binary push-button (RST-BUT) input to the DDC Hardware, via a remote command to the DDC Hardware via SNVT or both (where the Contractor provides both reset functions and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.4.4.4.4 Pressure Control

When this loop is enabled the DDC Hardware shall modulate the pump variable frequency drive unit to maintain the pipe system pressure at setpoint as shown, as measured by the differential pressure tap and sensor as shown. When this loop is disabled, the DDC Hardware capacity modulation output to the VFD shall be zero percent.

3.5 CONTROLLER TUNING

Tune each controller in a manner consistent with that described in the ASHRAE FUN SI ASHRAE FUN IP. 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. Set the controller to its correct setpoint and record and submit the final PID configuration settings with the O&M Instructions and on the associated Points Schedule.

3.6 START-UP AND START-UP TEST

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

3.6.1 General

Adjust, calibrate, measure, program, configure, set the time schedules, and otherwise perform all necessary actions to ensure that the systems function as specified and shown in the sequence of operation and other contract documents.

3.6.1.1 Systems Check

An item-by-item check shall be performed for each HVAC system;

****

NOTE: If the specification has been edited to include M&C Software (from Section 25 10 10), include the requirement to inspect M&C Clients to make sure they display shutdown conditions.

****

3.6.1.1.1 Step 1 - System Inspection

With the system in unoccupied mode and with fan hand-off-auto switches in the OFF position, 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 each M&C Client] shall be inspected to verify that all displays indicate shutdown conditions.

3.6.1.1.2 Step 2 - Calibration 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 value from the test instrument to the corresponding SNVT. 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 sensor 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 unoccupied mode with fan hand-off-auto switches in the OFF position, 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.

3.6.1.1.3 Step 3 - 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 over its 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.

3.6.1.2 Weather Dependent Test

Weather dependent test procedures shall be performed in the appropriate climatic season.

3.6.2 Start-Up and Start-Up Testing Report

Submit [4] [_____] copies of the Start-Up and Start-Up Testing Report. The report may be submitted as a Technical Data Package 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).

3.6.3 Draft LNS Database

Upon completion of the Start-Up Test, submit the Draft LNS Database reflecting the system as installed and configured at the completion of the Start-Up and Start-Up-Testing. Submit two copies of the fully commissioned, draft LNS Database (including all LNS credits) for the complete control network provided under this specification as a Technical Data Package. Each copy shall be on optical disk 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. The submitted LNS Database shall consist of the entire folder structure of the LNS database (e.g. c:\Lm\DB\{database name}.

3.7 PERFORMANCE VERIFICATION TEST (PVT)

3.7.1 PVT Procedures

****

NOTE: The designer must decide whether to require a one-point accuracy check and/or inlet and outlet air temperature measurements. Project specific requirements should be added, particularly for problematic controls based on designer and user

experience.
****

Prepare PVT Procedures based on Section 25 08 10 Utility Monitoring and Control System Testing explaining 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. Submit [4] [_____] copies of the PVT Procedures. The PVT Procedures may be submitted as a Technical Data Package.

3.7.1.1 Sensor Accuracy Checks

[The PVT shall include a one-point accuracy check of each sensor.] [The PVT shall include inlet and outlet air temperature measurements for all AHU-dependent terminal units.]

3.7.1.2 Temporary User Interface

****
NOTE: In most cases, the building control system will not have an operational front end connected at the time of PVT and this Temporary User Interface is needed. Delete the requirement if the project includes a local building management interface, or if the building will be integrated to an installation wide UMCS prior to PVT.
****

A temporary user interface shall be installed for the duration of the PVT to provide user display of SNVTs and the ability to override SNVTs as shown on the Points Schedule.

3.7.1.3 Endurance Test

The PVT shall include a [one-week] [_____] endurance test during which the system is operated continuously.

****
NOTE: In most cases, the building control system will not have a means to poll all the points shown on the points schedule. Delete the requirement for the installation of a device at each BPOC location if the project includes a local building management interface, or if the building will be integrated to an installation wide UMCS prior to PVT.
****

a. Install a device at each BPOC location and configure the device to poll all points shown on the Points Schedule as available to the Utility Monitoring and Control System throughout the endurance test.

   (1) All points on the Points Schedule with an alarm condition shall be polled at 5 minute intervals.

   (2) All points on the Points Schedule required for trending, overrides or graphical displays shall be polled at 15 minute intervals.

b. The PVT Procedure shall describe a methodology to measure and trend the network bandwidth usage on all Building Control Network channels, including the backbone, during the endurance test to demonstrate that bandwidth usage is less than 70 percent on all channels.

3.7.1.4 Network Peak Bandwidth Test

The PVT shall include a test demonstrating that the building control network is capable of supporting poll requests for all points indicated on the Points Schedules as available to the UMCS within a 2 minute interval using the same methodology as the endurance test bandwidth testing.

3.7.1.5 PVT Equipment List

A control system performance verification test equipment list shall be included in the PVT Procedures 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

Demonstrate compliance of the control system with the contract documents. Using test plans and procedures approved by the Government, an LNS Network Configuration Tool software capable of reading and writing an LNS Database, and the approved Draft LNS Database, 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 PVT Plan and Draft As-Builts and completion of balancing. The tests shall not be conducted during scheduled seasonal off periods of base heating and cooling systems. If the system experiences any failures during the endurance test portion of the PVT the system shall be repaired and the endurance test portion of the PVT shall be repeated until the system operates continuously and without failure for the specified endurance test period.

3.7.3 PVT Report

Submit [4] [_____] copies of the PVT Report. The PVT Report may be submitted as a Technical Data Package documenting all tests performed during the PVT and their results. Failures and repairs shall be documented with test results.

3.7.4 Final LNS Database

Submit a Final LNS Database which shall be the complete, final, commissioned as-built database for the system.

3.8 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 01 78 00 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.

The integration of the system specified in this section into a Utility Monitoring and Control System including the re-addressing of devices on the network, shall not, of itself, alter the requirement for the one year maintenance and service period.

The changing of device configuration properties or the binding of network variables for supervisory control shall not, of itself, alter the requirement for the one year maintenance and service period.

All work performed after the submission of the final as-built LNS Database shall be performed using a Government furnished LNS database, which may not be identical to the submitted as-built database due to changes in binding, configuration properties or device addressing as a result of system integration. Unless otherwise approved, do not use any other database to perform work on the system.

3.8.1 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.

3.8.2 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.

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

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

d. Run system software diagnostics and correct diagnosed problems.

e. Resolve any previous outstanding problems.

3.8.4 Scheduled Work

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

3.8.5 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 01 78 00 CLOSEOUT SUBMITTALS.

3.8.6 Operation

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

3.8.7 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.

3.8.8 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.

3.8.9 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 Instructions and other documentation affected, and an updated copy of the LNS Database used to make the modifications shall be provided..

3.9 TRAINING

****

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.

****

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. [32] [_____] hours of training shall be conducted within 30 days after successful completion of the performance verification test. The training course shall be conducted at the project site and the Government reserves the right to make audio and visual recordings of the training sessions for later use. 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.

3.9.1 Training Documentation

****

NOTE: Designer must choose appropriate shop supervisor(s) to coordinate training attendance.

****

Prepare training documentation consisting of:

3.9.1.1 Course Attendee List

A List of course attendees which shall be developed in coordination with and signed by the [Controls][HVAC][Electrical] shop supervisor.

3.9.1.2 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. Training manuals shall be delivered for each trainee on the Course Attendee List with [2] [_____] additional copies delivered for archival at the project site. [2] [_____] copies of the Course Attendee List shall be delivered with the archival copies. The Training Documentation may be submitted as a Technical Data Package.

3.9.2 Training Course Content

For guidance in planning the required instruction, assume that attendees will have a high school education, 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 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, use of LNS Plug-ins, use of AGC Programming software, 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 Start-Up Testing Report shall be presented as benchmarks of HVAC control system performance by which to measure operation and maintenance effectiveness.

APPENDIX A

QC CHECKLIST

This checklist is not all-inclusive of the requirements of this specification and should not be interpreted as such.

This checklist is for (check one:)

Pre-Construction QC Checklist Submittal	(Items 1-4)	|____|
Post-Construction QC Checklist Submittal	(Items 1-11)	|____|
Close-out QC Checklist Submittal	(Items 1-18)	|____|

Initial and date each item in the spaces provided verifying that each requirement has been met.

Items verified for Pre-Construction, Post-Construction and Closeout QC Checklists Submittal:

1	All DDC Hardware (nodes) are numbered on Control System Schematic Drawings.	|___|	|______|
2	Signal lines on Control System Schematic are labeled with the signal type.	|___|	|______|
3	Local Display Panel (LDP) Locations are shown on Control System Schematic drawings.	|___|	|______|
4	Points Schedule drawings have been sub-divided by device (DDC Hardware), including DDC Hardware node numbers.	|___|	|______|

Items verified for Post-Construction and Closeout QC Checklist Submittal:

5	All DDC Hardware is installed on a TP/FT-10 local control bus.	|___|	|______|
6	All Application Specific Controllers (ASCs) are LonMark certified.	|___|	|______|
7	Communication between DDC Hardware is only via CEA-709.1-D using SNVTs. Other protocols and network variables other than SNVTs have not been used.	|___|	|______|
8	Explicit messaging has not been used.	|___|	|______|
9	System Scheduler functionality has been installed for all HVAC systems and default schedules have been configured at each System Scheduler.	|___|	|______|
10	All sequences are performed as specified using DDC Hardware.	|___|	|______|
11	Training schedule and course attendee list has been developed and coordinated with shops and submitted.	|___|	|______|

QC CHECKLIST

Items verified for Closeout QC Checklists Submittal:

12	Final As-built Drawings, including the Points Schedule drawings, accurately represent the final installed system.	|___|______|
13	LonWorks Network Services (LNS) Database is up-to-date and accurately represents the final installed system.	|___|______|
14	LNS Plug-ins have been submitted for all ASCs.	|___|______|
15	Programming software has been submitted for all General Purpose Programmable Controllers (GPPCs) and all Application Generic Controllers (AGCs).	|___|______|
16	All software has been licensed to the Government	|___|______|
17	O&M Instructions have been completed and submitted.	|___|______|
18	Training course has been completed.	|___|______|

____

(QC Representative Signature) (Date)

-- End of Section --