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USACE / NAVFAC / AFCEC / NASA **UFGS-23 09 93 (November 2015)**

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UFGS-23 09 23 (May 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION TABLE OF CONTENTS

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

SECTION 23 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL

11/15

PART 1 GENERAL

1.1 DEFINITIONS
1.2 SUBMITTALS

PART 2 PRODUCTS

PART 3 EXECUTION

3.1 SEQUENCES OF OPERATION FOR OCCUPANCY SCHEDULING
3.1.1 System Mode
3.1.2 System Scheduler Requirements
3.1.2.1 Scheduled Occupancy Input
3.1.2.2 Occupancy Override Input
3.1.2.3 Space Occupancy Inputs
3.1.2.4 Air Handler Occupancy Output
3.1.2.5 Terminal Unit Occupancy Output
3.1.2.6 Default Schedule
3.1.2.7 Communication Determination
3.1.3 System Scheduler Output Determination
3.1.3.1 Air Handler Occupancy Output
3.1.3.2 Terminal Unit Occupancy Output
3.1.4 Air Handler System Scheduling
3.1.5 Stand-Alone Terminal Unit Scheduling
3.2 SEQUENCES OF OPERATION FOR AIR HANDLING UNITS
3.2.1 All-Air Small Package Unitary System
3.2.1.1 Fan ON-AUTO Switch
3.2.1.1.1 ON
3.2.1.1.2 AUTO
3.2.1.2 HEAT-OFF-COOL[-EMERG HEAT] Switch
3.2.1.2.1 HEAT-COOL[-EMERG HEAT]
3.2.1.2.2 OFF
3.2.1.3 Occupancy Modes
3.2.1.3.1 Occupied
3.2.1.3.2 Unoccupied

3.2.1.4 Safeties
3.2.1.5 Zone Temperature Control
3.2.2 Heating and Ventilating Unit (or Unit Ventilator)
3.2.2.1 HAND-OFF-AUTO Switches
3.2.2.1.1 HAND
3.2.2.1.2 OFF
3.2.2.1.3 AUTO
3.2.2.2 Occupancy Modes
3.2.2.2.1 Occupied
3.2.2.2.2 Unoccupied
3.2.2.3 System Enable and Loop Enable
3.2.2.3.1 Occupied Mode
3.2.2.3.2 Unoccupied Mode
3.2.2.4 Proofs and Safeties
3.2.2.4.1 Proofs
3.2.2.4.2 Safeties
3.2.2.4.3 DDC Hardware
3.2.2.5 Zone Temperature Control
3.2.2.5.1 Enabled Loop
3.2.2.5.2 Disabled Loop
3.2.2.6 Mixed Air Damper Control
3.2.3 Single Zone with Heating and [DX]Cooling Coils
3.2.3.1 HAND-OFF-AUTO Switch
3.2.3.1.1 HAND
3.2.3.1.2 OFF
3.2.3.1.3 AUTO
3.2.3.2 Occupancy Modes
3.2.3.3 System Enable and Loop Enable
3.2.3.3.1 Occupied Mode
3.2.3.3.2 Unoccupied Mode
3.2.3.3.3 Warm Up / Cool Down Mode
3.2.3.4 Proofs and Safeties
3.2.3.4.1 Proofs
3.2.3.4.2 Safeties
3.2.3.4.3 DDC Hardware
3.2.3.5 Minimum Outside Air Flow Control
3.2.3.6 Economizer Damper Control
3.2.3.6.1 Enabled Loop
3.2.3.6.2 Disabled Loop
3.2.3.6.3 Economizer Enable Logic
3.2.3.7 Heating Coil Control
3.2.3.8 [DX]Cooling Coil Control
3.2.4 Single Zone with Dual-Temperature Coil
3.2.4.1 HAND-OFF-AUTO Switch
3.2.4.1.1 HAND
3.2.4.1.2 OFF
3.2.4.1.3 AUTO
3.2.4.2 Occupancy Modes
3.2.4.3 System Enable and Loop Enable
3.2.4.3.1 Occupied Mode
3.2.4.3.2 Unoccupied Mode
3.2.4.3.3 Warm Up / Cool Down Mode
3.2.4.4 Proofs and Safeties
3.2.4.4.1 Proofs
3.2.4.4.2 Safeties
3.2.4.4.3 DDC Hardware
3.2.4.5 Minimum Outside Air Flow Control
3.2.4.6 Economizer Damper Control
3.2.4.6.1 Enabled Loop

3.2.4.6.2 Disabled Loop
3.2.4.6.3 Economizer Enable Logic
3.2.4.7 Dual Temperature Coil Control
3.2.4.7.1 Enabled Loop
3.2.4.7.2 DDC Hardware
3.2.4.7.3 Disabled Loop
3.2.5 Single Zone with Heating and Cooling Coils and Return Air Bypass
3.2.5.1 HAND-OFF-AUTO Switch
3.2.5.1.1 HAND
3.2.5.1.2 OFF
3.2.5.1.3 AUTO
3.2.5.2 Occupancy Modes
3.2.5.3 System Enable and Loop Enable
3.2.5.3.1 Occupied Mode
3.2.5.3.2 Unoccupied Mode
3.2.5.3.3 Warm Up / Cool Down Mode
3.2.5.4 Proofs and Safeties
3.2.5.4.1 Proofs
3.2.5.4.2 Safeties
3.2.5.4.3 DDC Hardware
3.2.5.5 Minimum Outside Air Flow Control
3.2.5.6 Economizer Damper Control
3.2.5.6.1 Enabled Loop
3.2.5.6.2 Disabled Loop
3.2.5.6.3 Economizer Enable Logic
3.2.5.7 Temperature Control Loop Heating Coil Control
3.2.6 Single Zone with Humidity Control
3.2.6.1 HAND-OFF-AUTO Switch
3.2.6.1.1 HAND
3.2.6.1.2 OFF
3.2.6.1.3 AUTO
3.2.6.2 Occupancy Modes
3.2.6.3 System Enable and Loop Enable
3.2.6.3.1 Occupied Mode
3.2.6.3.2 Unoccupied Mode
3.2.6.3.3 Warm Up / Cool Down Mode
3.2.6.4 Proofs and Safeties
3.2.6.4.1 Proofs
3.2.6.4.2 Safeties
3.2.6.4.3 DDC Hardware
3.2.6.5 Minimum Outside Air Flow Control
3.2.6.6 Preheat Coil Control Loop
3.2.6.7 Cooling-and-Dehumidification Coil Control
3.2.6.8 Reheat Coil Control
3.2.6.9 Humidification Control
3.2.7 Multizone [Dual-Duct] [with][without] Return Fan
3.2.7.1 HAND-OFF-AUTO switches and Fire Alarm Panel (FAP) Signal
3.2.7.1.1 HAND
3.2.7.1.2 OFF
3.2.7.1.3 AUTO
3.2.7.2 Return Fan VFD
3.2.7.3 Occupancy Modes
3.2.7.4 System Enable and Loop Enable
3.2.7.4.1 Occupied Mode
3.2.7.4.2 Unoccupied Mode
3.2.7.4.3 Warm Up / Cool Down Mode
3.2.7.5 Proofs and Safeties
3.2.7.5.1 Proofs

3.2.7.5.2 Safeties
3.2.7.5.3 DDC Hardware Reset
3.2.7.6 Minimum Outside Air Flow Control
3.2.7.7 Mixed Air Temperature Control With Economizer
3.2.7.7.1 Enabled Loop
3.2.7.7.2 Disabled Loop
3.2.7.7.3 Economizer Enable Logic
3.2.7.8 Hot Deck Coil Control
3.2.7.8.1 Enabled Loop
3.2.7.8.2 DDC Hardware Reset
3.2.7.9 Cold Deck Coil Control
3.2.7.10 Zone Temperature Control
3.2.7.10.1 Zone Temperature Setpoint
3.2.7.10.2 DDC Hardware Modulation
3.2.8 Multizone with Hot Deck Bypass [with][without] Return Fan
3.2.8.1 HAND-OFF-AUTO Switches
3.2.8.1.1 HAND
3.2.8.1.2 OFF
3.2.8.1.3 AUTO
3.2.8.2 Return Fan Motor Starter
3.2.8.2.1 HAND
3.2.8.2.2 OFF
3.2.8.2.3 AUTO
3.2.8.3 Occupancy Modes
3.2.8.4 System Enable and Loop Enable
3.2.8.4.1 Occupied Mode
3.2.8.4.2 Unoccupied Mode
3.2.8.4.3 Warm Up / Cool Down Mode
3.2.8.5 Proofs and Safeties
3.2.8.5.1 Proofs
3.2.8.5.2 Safeties
3.2.8.5.3 DDC Hardware Reset
3.2.8.6 Minimum Outside Air Flow Control
3.2.8.7 Mixed Air Temperature Control With Economizer
3.2.8.7.1 Enabled Loop
3.2.8.7.2 Disabled Loop
3.2.8.7.3 Economizer Enable Logic
3.2.8.8 Cold Deck Coil Control
3.2.8.9 Zone Temperature Control
3.2.9 Variable Air Volume System [with][without] Return Fan
3.2.9.1 HAND-OFF-AUTO Switches
3.2.9.1.1 HAND
3.2.9.1.2 OFF
3.2.9.1.3 AUTO
3.2.9.2 Return Fan Variable Frequency Drive
3.2.9.2.1 HAND
3.2.9.2.2 OFF
3.2.9.2.3 AUTO
3.2.9.3 Occupancy Modes
3.2.9.4 Proofs and Safeties
3.2.9.4.1 Proofs
3.2.9.4.2 Safeties
3.2.9.4.3 DDC Hardware Reset
3.2.9.5 System Enable and Loop Enable
3.2.9.5.1 Occupied Mode
3.2.9.5.2 Unoccupied Mode
3.2.9.5.3 Warm Up/Cool Down
3.2.9.6 Fan Capacity Control
3.2.9.6.1 Supply Duct Static Pressure Control

3.2.9.6.2 Return Fan Volume Control
3.2.9.7 Minimum Outside Air Flow Control
3.2.9.8 Mixed Air Temperature Control With Economizer
3.2.9.8.1 Enabled Loop
3.2.9.8.2 Disabled Loop
3.2.9.8.3 Economizer Enable Logic
3.2.9.9 Cooling Coil Control
3.2.9.10 Preheat Coil Control
3.3 SEQUENCES OF OPERATION FOR TERMINAL UNITS
3.3.1 Zone Temperature Control - Cooling-Only VAV Box
3.3.1.1 Occupancy Modes
3.3.1.1.1 Occupied
3.3.1.1.2 Unoccupied
3.3.1.2 Zone Temperature Control
3.3.1.2.1 Occupied Mode
3.3.1.2.2 Unoccupied Mode
3.3.2 Zone Temperature Control - VAV Box with Reheat
3.3.2.1 Occupancy Modes
3.3.2.1.1 Occupied
3.3.2.1.2 Unoccupied
3.3.2.2 Safeties
3.3.2.3 Zone Temperature Control
3.3.3 Zone Temperature Control - Fan Powered VAV Box
3.3.3.1 Occupancy Modes
3.3.3.1.1 Occupied
3.3.3.1.2 Unoccupied
3.3.3.2 Safeties
3.3.3.3 Fan Control
3.3.3.4 Zone Temperature Control
3.3.3.4.1 Occupied Mode
3.3.3.4.2 Unoccupied Mode
3.3.3.4.3 Sequencing
3.3.3.4.3.1 Cooling Mode
3.3.3.4.3.2 Heating Mode
3.3.4 Perimeter Radiation Control Sequence
3.3.4.1 Occupancy Modes
3.3.4.1.1 Occupied
3.3.4.1.2 Unoccupied
3.3.4.2 Safeties
3.3.4.3 Space Temperature Control
3.3.4.3.1 Occupieed Mode
3.3.4.3.2 Unoccupied Mode
3.3.5 Unit Heater and Cabinet Unit Heater
3.3.5.1 Off-Auto Switch
3.3.5.1.1 OFF
3.3.5.1.2 AUTO
3.3.5.2 Occupancy Modes
3.3.5.2.1 Occupied
3.3.5.2.2 Unoccupied
3.3.5.3 Safeties
3.3.5.4 Space Temperature Control
3.3.5.4.1 Occupied Mode
3.3.5.4.2 Unoccupied Mode
3.3.6 Gas-Fired Infrared Heater
3.3.6.1 On-Off-Auto Switch
3.3.6.1.1 ON
3.3.6.1.2 OFF
3.3.6.1.3 AUTO
3.3.6.2 Occupancy Modes

3.3.6.2.1 Occupied
3.3.6.2.2 Unoccupied
3.3.6.3 Safeties
3.3.6.4 Space Temperature Control
3.3.6.4.1 Occupied Mode
3.3.6.4.2 Unoccupied Mode
3.3.7 Dual Temperature Fan-Coil Unit
3.3.7.1 Off-Auto Switch
3.3.7.1.1 OFF
3.3.7.1.2 AUTO
3.3.7.2 Occupancy Modes
3.3.7.2.1 Occupied
3.3.7.2.2 Unoccupied
3.3.7.3 Heat/Cool Modes
3.3.7.4 Safeties
3.3.7.5 Space Temperature Control
3.3.7.5.1 Occupied Mode
3.3.7.5.2 Unoccupied Mode
3.4 SEQUENCES OF OPERATION FOR HYDRONIC SYSTEMS
3.4.1 Hydronic Heating Hot Water from Distributed [Steam][HTHW] Converter
3.4.1.1 System Enable and Loop Enable
3.4.1.2 HAND-OFF-AUTO Switch
3.4.1.2.1 HAND
3.4.1.2.2 OFF
3.4.1.2.3 AUTO
3.4.1.3 Proofs and Safeties
3.4.1.3.1 Proofs
3.4.1.3.2 Safeties
3.4.1.3.3 DDC Hardware Reset
3.4.1.4 Heat Exchanger Valve Control
3.4.2 Hydronic Heating Hot Water From Single-Building Boiler
3.4.2.1 System Enable and Loop Enable
3.4.2.2 HAND-OFF-AUTO Switch
3.4.2.2.1 HAND
3.4.2.2.2 OFF
3.4.2.2.3 AUTO
3.4.2.3 Proofs and Safeties
3.4.2.3.1 Proofs
3.4.2.3.2 Safeties
3.4.2.3.3 DDC Hardware Reset
3.4.2.4 Boiler Control
3.4.2.5 Hot Water Temperature Control
3.4.3 Hydronic Dual-Temperature System with [Steam][High Temperature Hot Water] Heat Exchanger and Chilled Water
3.4.3.1 System Enable and Loop Enable
3.4.3.2 Switchover Valve Operation
3.4.3.2.1 HEATING/COOLING Switch in the HEATING Position
3.4.3.2.2 HEATING/COOLING Switch in the COOLING Position
3.4.3.3 HAND-OFF-AUTO Switch
3.4.3.3.1 HAND
3.4.3.3.2 OFF
3.4.3.3.3 AUTO
3.4.3.4 Proofs and Safeties
3.4.3.4.1 Proofs
3.4.3.4.2 Safeties
3.4.3.4.3 DDC Hardware Reset
3.4.3.5 [Heat Exchanger][Mixing] Valve Control
3.4.4 Hydronic Secondary with Variable Speed Pump

3.4.4.1 System Enable and Loop Enable
3.4.4.2 HAND-OFF-AUTO Switch
3.4.4.2.1 HAND
3.4.4.2.2 OFF
3.4.4.2.3 AUTO
3.4.4.3 Proofs and Safeties
3.4.4.3.1 Proofs
3.4.4.3.2 Safeties
3.4.4.3.3 DDC Hardware Reset
3.4.4.4 Pressure Control

-- End of Section Table of Contents --

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SECTION 23 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL
11/15

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NOTE: This guide specification covers the requirements for sequences of operation for HVAC control.

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 item(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).
****

****
NOTE: This Section contains only Sequences of Operation and cannot be used stand-alone (without the use of other Sections). This Section is intended to be used with Section 23 09 00.

Template drawings and Points Schedule in electronic format for use with this section are available in online at:
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/for
****

****
NOTE: The Sequences of Operation in this Section are being updated, and this Section will soon be revised to include the updated sequences.
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PART 1 GENERAL

1.1 DEFINITIONS

For definitions related to this Section, see Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

1.2 SUBMITTALS

Submittals related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC.

PART 2 PRODUCTS

Products related to this Section are specified in Section 23 09 00 INTRUMENTATION AND CONTROL FOR HVAC and related Sections 23 09 13 INSTRUMENTATION AND CONTROL DEVICES FOR HVAC and 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS or 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS.

PART 3 EXECUTION

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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"*.

****

3.1 SEQUENCES OF OPERATION FOR OCCUPANCY SCHEDULING

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

****

3.1.1 System Mode

Operate air handling units (AHUs) in Occupied, Warm-Up-Cool-Down, or Unoccupied modes as specified. VAV boxes, Fan Coils, and operate other terminal equipment 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.

3.1.2 System Scheduler Requirements

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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).

These sequences include details specific to the LonWorks protocol. When using other protocols, edit sequences accordingly.

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The System Scheduler functionality must 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. Provide a unique System Scheduler 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 must provide the following functionality:

3.1.2.1 Scheduled Occupancy Input

Accept network variable of type SNVT_occupancy. Support the following possible values: OC_STANDBY, OC_OCCUPIED and OC_UNOCCUPIED.

3.1.2.2 Occupancy Override Input

Accept network variable of type SNVT_occupancy. Support the following possible values: OC_STANDBY, OC_OCCUPIED, OC_UNOCCUPIED, and OC_NUL.

3.1.2.3 Space Occupancy Inputs

For systems with multiple occupancy sensors, accept multiple inputs of network variable type SNVT_Occupancy. 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.

3.1.2.4 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.

3.1.2.5 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.

3.1.2.6 Default Schedule

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NOTE: Designer must provide the default (backup) 24-hour 7-day schedule on the Points Schedule (i.e. Occupied from 0600 - 2200 Monday through Friday, Unoccupied Saturday and Sunday).

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

3.1.2.7 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).

3.1.3 System Scheduler Output Determination

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

3.1.3.1 Air Handler Occupancy Output

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

a. If the Override Occupancy Input is not OC_NUL, determine the Air Handler Occupancy Output 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 must be OC_OCCUPIED.

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

3.1.3.2 Terminal Unit Occupancy Output

If more than 95 minutes have passed since the last receipt of the Scheduled Occupancy input, determine the Terminal Unit Occupancy Output by

the default schedule. Otherwise, determine the output as follows:

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

b. Otherwise, determine the Terminal Unit Occupancy Output from the Scheduled Occupancy SNVT.

3.1.4 Air Handler System Scheduling

a. Bind the AHU Occupancy Output SNVT 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, bind the output SNVT (of type SNVT_Occupancy) of each occupancy sensor to a Space Occupancy Input of the System Scheduler.

c. Bind the Terminal Unit Occupancy Output SNVT from the System Scheduler to each AHU-Dependent Terminal Unit.

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

3.1.5 Stand-Alone Terminal Unit Scheduling

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

3.2 SEQUENCES OF OPERATION FOR AIR HANDLING UNITS

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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).

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3.2.1 All-Air Small Package Unitary System

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

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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 must be proportional-integral (PI) control.

3.2.1.1 Fan ON-AUTO Switch

3.2.1.1.1 ON

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

3.2.1.1.2 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.

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

3.2.1.2.1 HEAT-COOL[-EMERG HEAT]

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

3.2.1.2.2 OFF

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

3.2.1.3 Occupancy Modes

3.2.1.3.1 Occupied

The unit DDC Hardware must 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.

3.2.1.3.2 Unoccupied

The unit DDC Hardware must 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.

3.2.1.4 Safeties

Run the unit subject to the unit manufacturer's safeties.

3.2.1.5 Zone Temperature Control

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

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

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

3.2.2 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 must be proportional-integral (PI) control.

3.2.2.1 HAND-OFF-AUTO Switches

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

3.2.2.1.1 HAND

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

3.2.2.1.2 OFF

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

3.2.2.1.3 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.

3.2.2.2 Occupancy Modes

Obtain the system's Occupancy Mode input from the System Scheduler as specified and indicated. Operate the system in one of the following modes:

3.2.2.2.1 Occupied

The Unit's DDC Hardware must 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].

3.2.2.2.2 Unoccupied

The Unit's DDC Hardware must 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].

3.2.2.3 System Enable and Loop Enable

3.2.2.3.1 Occupied Mode

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

Enabe the supply fan (SYS-ENA) and command to run (SF-SS). Enable the Zone Temperature Control loop [and Mixed Air Damper Control].

3.2.2.3.2 Unoccupied Mode

Disable all control loops. When BLDG-T drops below BLDG-T-LL-SP (with a 3 degrees C 5 degrees F deadband) enable the supply fan (SYS-ENA) and command to run (SF-SS) and enable the Zone Temperature Control loop.

3.2.2.4 Proofs and Safeties

Subject the supply fan and all DDC Hardware control loops to Proofs and Safeties. Direct-hardwire interlock safeties to the fan starter circuit as indicated. DDC Hardware must monitor all proofs and safeties and failure of any proof or activation of any safety must result in all control loops being disabled and the AHU fan being commanded off until reset.

3.2.2.4.1 Proofs

Supply fan status (proof) (SF-S)

3.2.2.4.2 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)]

3.2.2.4.3 DDC Hardware

DDC Hardware reset all proofs and safeties 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 indicated on the Points Schedule drawing.

3.2.2.5 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.

****

3.2.2.5.1 Enabled Loop

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

3.2.2.5.2 Disabled Loop

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

[3.2.2.6 Mixed Air Damper Control

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

]3.2.3 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 must be proportional-integral (PI) control.

3.2.3.1 HAND-OFF-AUTO Switch

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

3.2.3.1.1 HAND

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

3.2.3.1.2 OFF

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

3.2.3.1.3 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.

3.2.3.2 Occupancy Modes

Obtain the system's Occupancy Mode input from the System Scheduler as specified and indicated. Operate the system in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.2.3.3 System Enable and Loop Enable

3.2.3.3.1 Occupied Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS) and enable all control loops.

3.2.3.3.2 Unoccupied Mode

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

[3.2.3.3.3 Warm Up / Cool Down Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS) and disable the Minimum Outside Air Flow Control loop. Enable all other control loops.

]3.2.3.4 Proofs and Safeties

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

3.2.3.4.1 Proofs

Supply fan status (proof) (SF-S)

3.2.3.4.2 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)

3.2.3.4.3 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.

3.2.3.5 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.

3.2.3.6 Economizer Damper Control

3.2.3.6.1 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.

3.2.3.6.2 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.

3.2.3.6.3 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.

3.2.3.7 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.

3.2.3.8 [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].

3.2.4 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.

3.2.4.1 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:

3.2.4.1.1 HAND

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

3.2.4.1.2 OFF

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

3.2.4.1.3 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.

3.2.4.2 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].

3.2.4.3 System Enable and Loop Enable

3.2.4.3.1 Occupied Mode

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

3.2.4.3.2 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.

[3.2.4.3.3 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.

]3.2.4.4 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.

3.2.4.4.1 Proofs

Supply fan status (proof) (SF-S)

3.2.4.4.2 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)

3.2.4.4.3 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.

3.2.4.5 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.

3.2.4.6 Economizer Damper Control

3.2.4.6.1 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.

3.2.4.6.2 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.

3.2.4.6.3 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.

3.2.4.7 Dual Temperature Coil Control

3.2.4.7.1 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.

3.2.4.7.2 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.

3.2.4.7.3 Disabled Loop

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

3.2.5 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.

3.2.5.1 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:

3.2.5.1.1 HAND

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

3.2.5.1.2 OFF

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

3.2.5.1.3 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.

3.2.5.2 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].

3.2.5.3 System Enable and Loop Enable

3.2.5.3.1 Occupied Mode

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

3.2.5.3.2 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.

[3.2.5.3.3 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.

]3.2.5.4 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.

3.2.5.4.1 Proofs

Supply fan status (proof) (SF-S)

3.2.5.4.2 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)

3.2.5.4.3 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.

3.2.5.5 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.

3.2.5.6 Economizer Damper Control

3.2.5.6.1 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.

3.2.5.6.2 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.

3.2.5.6.3 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.

3.2.5.7 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.

3.2.6 Single Zone with Humidity Control

****

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.

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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.

3.2.6.1 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 indicated. The supply fan motor starter shall have an H-O-A switch:

3.2.6.1.1 HAND

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

3.2.6.1.2 OFF

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

3.2.6.1.3 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.

3.2.6.2 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].

3.2.6.3 System Enable and Loop Enable

3.2.6.3.1 Occupied Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS) and enable all control loops.

3.2.6.3.2 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.

[3.2.6.3.3 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.

]3.2.6.4 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.

3.2.6.4.1 Proofs

Supply fan status (proof) (SF-S)

3.2.6.4.2 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)

3.2.6.4.3 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 both reset functions are provided and the operator can use either one to perform the reset), as shown on the Points Schedule drawing.

3.2.6.5 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.

3.2.6.6 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.

3.2.6.7 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.

3.2.6.8 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.

3.2.6.9 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.

3.2.7 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.

3.2.7.1 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:

3.2.7.1.1 HAND

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

3.2.7.1.2 OFF

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

3.2.7.1.3 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.

[3.2.7.2 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.

]3.2.7.3 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].

3.2.7.4 System Enable and Loop Enable

3.2.7.4.1 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.

3.2.7.4.2 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.

[3.2.7.4.3 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.

]3.2.7.5 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.

3.2.7.5.1 Proofs

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

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

3.2.7.5.2 Safeties

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

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

c. Return air smoke (RA-SMK)]

3.2.7.5.3 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.

3.2.7.6 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.

3.2.7.7 Mixed Air Temperature Control With Economizer

3.2.7.7.1 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.

3.2.7.7.2 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.

3.2.7.7.3 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.

3.2.7.8 Hot Deck Coil Control

3.2.7.8.1 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.

[3.2.7.8.2 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].

]3.2.7.9 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.

3.2.7.10 Zone Temperature Control

When this loop is enabled:

3.2.7.10.1 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.

3.2.7.10.2 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).

3.2.8 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 indicated on the Points Schedule. Unless otherwise specified, all modulating control must be proportional-integral (PI) control.

3.2.8.1 HAND-OFF-AUTO Switches

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

3.2.8.1.1 HAND

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

3.2.8.1.2 OFF

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

3.2.8.1.3 AUTO

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

[3.2.8.2 Return Fan Motor Starter

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

3.2.8.2.1 HAND

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

3.2.8.2.2 OFF

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

3.2.8.2.3 AUTO

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

]3.2.8.3 Occupancy Modes

Obtain the system's Occupancy Mode input from the System Scheduler as specified and indicated. Operate the system in one of the following modes: Occupied, Unoccupied[, or WarmUp/CoolDown].

3.2.8.4 System Enable and Loop Enable

3.2.8.4.1 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.

3.2.8.4.2 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.

[3.2.8.4.3 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.

]3.2.8.5 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.

3.2.8.5.1 Proofs

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

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

3.2.8.5.2 Safeties

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

b. Supply air smoke (SA-SMK)

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

3.2.8.5.3 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.

3.2.8.6 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.

3.2.8.7 Mixed Air Temperature Control With Economizer

3.2.8.7.1 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.

3.2.8.7.2 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.

3.2.8.7.3 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.

3.2.8.8 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.

3.2.8.9 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.

3.2.9 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.
****

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.

3.2.9.1 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:

3.2.9.1.1 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.

3.2.9.1.2 OFF

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

3.2.9.1.3 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.

[3.2.9.2 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:

3.2.9.2.1 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.

3.2.9.2.2 OFF

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

3.2.9.2.3 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.

]3.2.9.3 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].

3.2.9.4 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.

3.2.9.4.1 Proofs

a. Supply fan status (SF-S)

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

3.2.9.4.2 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)

3.2.9.4.3 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.

3.2.9.5 System Enable and Loop Enable

3.2.9.5.1 Occupied Mode

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

3.2.9.5.2 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.

[3.2.9.5.3 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.

]3.2.9.6 Fan Capacity Control

3.2.9.6.1 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.

[3.2.9.6.2 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.

]3.2.9.7 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.

3.2.9.8 Mixed Air Temperature Control With Economizer

3.2.9.8.1 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.

3.2.9.8.2 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.

3.2.9.8.3 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.

3.2.9.9 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.

[3.2.9.10 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.

]3.3 SEQUENCES OF OPERATION FOR TERMINAL UNITS

****

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).

****

3.3.1 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.

3.3.1.1 Occupancy Modes

3.3.1.1.1 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.

3.3.1.1.2 Unoccupied

The VAV box DDC Hardware must 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.

3.3.1.2 Zone Temperature Control

3.3.1.2.1 Occupied Mode

In the Occupied Mode the zone temperature setpoint (ZN-T-SP) must be at the configured setpoint or at the occupant-adjustable setpoint via the wall-mounted thermostat, as shown. The DDC Hardware must 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. Sequenceas indicated: Upon a rise in zone temperature (ZN-T) above zone setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as indicated, adjust the airflow setpoint between minimum and maximum flow based on the difference between zone temperature and zone temperature setpoint as indicated.

3.3.1.2.2 Unoccupied Mode

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

3.3.2 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.

3.3.2.1 Occupancy Modes

3.3.2.1.1 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.

3.3.2.1.2 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.

3.3.2.2 Safeties

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

3.3.2.3 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.

3.3.3 Zone Temperature Control - Fan Powered VAV Box

****

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

As specified in Section 23 30 00 HVAC AIR DISTRIBUTION, 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.

****

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.

3.3.3.1 Occupancy Modes

3.3.3.1.1 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.

3.3.3.1.2 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.

3.3.3.2 Safeties

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

3.3.3.3 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.]

3.3.3.4 Zone Temperature Control

3.3.3.4.1 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.

3.3.3.4.2 Unoccupied Mode

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

3.3.3.4.3 Sequencing

3.3.3.4.3.1 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.

3.3.3.4.3.2 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.

3.3.4 Perimeter Radiation Control Sequence

****

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

****

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.

3.3.4.1 Occupancy Modes

3.3.4.1.1 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.

3.3.4.1.2 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.

3.3.4.2 Safeties

This system has no safeties.

3.3.4.3 Space Temperature Control

3.3.4.3.1 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.

3.3.4.3.2 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.

3.3.5 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.

3.3.5.1 Off-Auto Switch

3.3.5.1.1 OFF

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

3.3.5.1.2 AUTO

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

3.3.5.2 Occupancy Modes

3.3.5.2.1 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.

3.3.5.2.2 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.

3.3.5.3 Safeties

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

3.3.5.4 Space Temperature Control

3.3.5.4.1 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.

3.3.5.4.2 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.

3.3.6 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.

3.3.6.1 On-Off-Auto Switch

3.3.6.1.1 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.

3.3.6.1.2 OFF

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

3.3.6.1.3 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.

3.3.6.2 Occupancy Modes

3.3.6.2.1 Occupied

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

3.3.6.2.2 Unoccupied

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

3.3.6.3 Safeties

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

3.3.6.4 Space Temperature Control

3.3.6.4.1 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 indicated.

3.3.6.4.2 Unoccupied Mode

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

3.3.7 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.

3.3.7.1 Off-Auto Switch

3.3.7.1.1 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.

3.3.7.1.2 AUTO

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

3.3.7.2 Occupancy Modes

3.3.7.2.1 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.

3.3.7.2.2 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.

3.3.7.3 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.

3.3.7.4 Safeties

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

3.3.7.5 Space Temperature Control

3.3.7.5.1 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 indicated.

3.3.7.5.2 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 indicated.

3.4 SEQUENCES OF OPERATION FOR HYDRONIC SYSTEMS

3.4.1 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 must be proportional-integral (PI) control.

3.4.1.1 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) command the hot water pump 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, enable the Heat Exchanger Control loop.

3.4.1.2 HAND-OFF-AUTO Switch

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

3.4.1.2.1 HAND

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

3.4.1.2.2 OFF

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

3.4.1.2.3 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.

3.4.1.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.1.3.1 Proofs

Hot water pump status (HW-PMP-S)

3.4.1.3.2 Safeties

None

3.4.1.3.3 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 indicated on the Points Schedule drawing.

3.4.1.4 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.

3.4.2 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.

3.4.2.1 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.

3.4.2.2 HAND-OFF-AUTO Switch

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

3.4.2.2.1 HAND

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

3.4.2.2.2 OFF

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

3.4.2.2.3 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.

3.4.2.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.2.3.1 Proofs

Hot water pump

3.4.2.3.2 Safeties

None

3.4.2.3.3 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.

3.4.2.4 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.

3.4.2.5 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.

3.4.3 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.

3.4.3.1 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.]

3.4.3.2 Switchover Valve Operation

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

3.4.3.2.1 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].

3.4.3.2.2 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).

3.4.3.3 HAND-OFF-AUTO Switch

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

3.4.3.3.1 HAND

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

3.4.3.3.2 OFF

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

3.4.3.3.3 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.

3.4.3.4 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.3.4.1 Proofs

None

3.4.3.4.2 Safeties

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

3.4.3.4.3 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.

[3.4.3.5 [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 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.

3.4.4.1 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.

3.4.4.2 HAND-OFF-AUTO Switch

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

3.4.4.2.1 HAND

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

3.4.4.2.2 OFF

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

3.4.4.2.3 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.

3.4.4.3 Proofs and Safeties

DDC Hardware shall monitor all proofs and safeties.

3.4.4.3.1 Proofs

None

3.4.4.3.2 Safeties

None

3.4.4.3.3 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 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.

-- End of Section --