Preparing Activity: USACE Superseding
UFGS-23 09 23 (May 2011)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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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).
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****
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
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****
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"*.

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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.

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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

Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as indicated. Provide supply fan motor starter with 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, ensure outside air damper minimum position (OA-D-MIN) is 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

Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as indicated. Provide supply fan motor starter with 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

Provide DDC Hardware reset of 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 shown on the Points Schedule drawing.

3.2.3.5 Minimum Outside Air Flow Control

When this loop is enabled, 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 will 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 will 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 will be closed, and the return air damper will be open.

3.2.3.6.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP each have a 1 degree C 2 degrees F deadband.

3.2.3.7 Heating Coil Control

When this loop is enabled, 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 is closed.

3.2.3.8 [DX]Cooling Coil Control

When this loop is enabled the DDC Hardware must [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 is off] [cooling coil control valve is 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 must be proportional-integral (PI) control.

3.2.4.1 HAND-OFF-AUTO Switch

Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as indicated. Provide supply fan motor starter with 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

Obtain Occupancy Mode input from the System Scheduler as specified and shown. Operate the system 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

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

3.2.4.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the building low limit setpoint (BLDG-T-LL), disable all control loops and do not run the supply fan. 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 Dual Temperature Coil Temperature Control loop. Disable the Minimum Outside Air Flow Control and Economizer Damper Control loops.

[3.2.4.3.3 Warm Up / Cool Down Mode

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

]3.2.4.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops are subject to Proofs and Safeties. Direct-hardwire interlock safeties to the fan starter circuit as shown. Monitor all proofs and safeties, and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 shown on the Points Schedule drawing.

3.2.4.5 Minimum Outside Air Flow Control

When this loop is enabled, open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, close the minimum outside air damper.

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, 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, close the economizer outside air and relief air dampers, and open the return air damper.

3.2.4.6.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP 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, 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

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, close the control valve.

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 are proportional-integral (PI) control.

3.2.5.1 HAND-OFF-AUTO Switch

Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as indicated. Provide supply fan motor starter with an H-O-A switch:

3.2.5.1.1 HAND

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

3.2.5.1.2 OFF

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

3.2.5.1.3 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.

3.2.5.2 Occupancy Modes

Obtain the Occupancy Mode input from the System Scheduler as specified and shown. Operate the system 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

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

3.2.5.3.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) disable all control loops and do not run the supply fan. 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 all other control loops.

[3.2.5.3.3 Warm Up / Cool Down Mode

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

]3.2.5.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops are subject to Proofs and Safeties. Direct-hardwire interlock safeties to the fan starter circuit as shown. Monitor all proofs and safeties and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 shown on the Points Schedule drawing.

3.2.5.5 Minimum Outside Air Flow Control

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

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, 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, close the economizer outside air and relief air dampers, and open the return air damper.

3.2.5.6.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP 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, 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, close both valves and position the bypass and supply air dampers 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.
****

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 are proportional-integral (PI) control.

3.2.6.1 HAND-OFF-AUTO Switch

Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as indicated. Provide supply fan motor starter with an H-O-A switch:

3.2.6.1.1 HAND

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

3.2.6.1.2 OFF

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

3.2.6.1.3 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.

3.2.6.2 Occupancy Modes

Obtain Occupancy Mode input from the System Scheduler as specified and shown. Operate the system 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), disable all control loops and do not run the supply fan. 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), enable the Preheat Coil Control loop and Reheat Coil Control loop and disable all other loops.

[3.2.6.3.3 Warm Up / Cool Down Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS). Disable the

Minimum Outside Air Flow Control loop and enable all other control loops.

]3.2.6.4 Proofs and Safeties

The supply fan and all DDC Hardware control loops are subject to Proofs and Safeties. Direct-hardwire interlock safeties to the fan starter circuit as shown. Monitor all proofs and safeties and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 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, open the 2-position minimum outside air damper to introduce the minimum outside air flow quantity as shown. When this loop is disabled, close the minimum outside air damper.

3.2.6.6 Preheat Coil Control Loop

When this loop is enabled, 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, close the preheat coil valve.

3.2.6.7 Cooling-and-Dehumidification Coil Control

When this loop is enabled, 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. Modulate the valve 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, close the coil valve.

3.2.6.8 Reheat Coil Control

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

close the coil valve.

3.2.6.9 Humidification Control

When this loop is enabled, modulate the humidifier valve to maintain zone relative humidity (ZN-RH) at setpoint (ZN-RH-SP). Modulate the valve 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, begin modulating the humidifier valve towards closed and continue to gradually move towards closed until the supply air duct humidity reaches 90 percent relative humidity, at which point the humidifier valve is fully closed. When this loop is disabled, close the humidifier valve.

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.

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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 are proportional-integral (PI) control.

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

Supply Fan VFD. Provide supply fan motor starter to accept a Fire Alarm Panel (FAP) signal that takes precedence over all other starter inputs and switches and starts the fan. Provide fan motor starter which accepts an occupant accessible emergency shutoff switch as shown. Provide supply fan motor starter with 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

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

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

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

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

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

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

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

]3.2.7.3 Occupancy Modes

Obtain Occupancy Mode input from the System Scheduler as specified and shown. Operate the system 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

Enable the supply fan (SYS-ENA) and command to run (SF-SS). Enable all control loops. Also enable the Zone Temperature Control loops serviced by the AHU.

3.2.7.4.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL), disable all control loops and do not run the supply fan. 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), enable the Hot Deck Coil Control loop and all Zone Temperature Control loops, and disable all other control loops.

[3.2.7.4.3 Warm Up / Cool Down Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS). Disable the Minimum Outside Air Flow Control loop and enable all other control loops. Also enable the Zone Temperature Control loops serviced by the AHU.

]3.2.7.5 Proofs and Safeties

The supply fan and all DDC Hardware control loops are subject to Proofs and Safeties. Direct-hardwire interlock safeties to the fan starter

circuit as shown. Monitor all proofs and safeties and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 shown on the Points Schedule drawing.

3.2.7.6 Minimum Outside Air Flow Control

When this loop is enabled, open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, close the minimum outside air damper.

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, 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, close the economizer outside air and relief air dampers, and open the return air damper.

3.2.7.7.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP 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, 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, close the hot deck coil valve.

[3.2.7.8.2 DDC Hardware Reset

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

]3.2.7.9 Cold Deck Coil Control

When this loop is enabled, 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, close the cold deck cooling coil valve.

3.2.7.10 Zone Temperature Control

When this loop is enabled:

3.2.7.10.1 Zone Temperature Setpoint

Ensure zone temperature setpoint (ZN-T-SP) is 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

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.

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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

Enable the supply fan (SYS-ENA) and command to run (SF-SS). Enable all control loops. Also enable the Zone Temperature Control loops serviced by the AHU.

3.2.8.4.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL), disable all control loops and do not run the supply fan. 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 all Zone Temperature Control loops. Disable the Minimum Outside Air Flow Control, Mixed Air Temperature Control With Economizer, and Cold Deck Coil Control loops.

[3.2.8.4.3 Warm Up / Cool Down Mode

Enable the supply fan (SYS-ENA) and command to run (SF-SS). Disable the Minimum Outside Air Flow Control loop and enable all other control loops. Also enable the Zone Temperature Control loops serviced by the AHU.

]3.2.8.5 Proofs and Safeties

The supply fan[, return fan,] and all DDC Hardware control loops are subject to Proofs and Safeties. Direct-hardwire interlocksafeties to the fan starter circuit as shown. Monitor all proofs and safeties and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 shown on the Points Schedule drawing.

3.2.8.6 Minimum Outside Air Flow Control

When this loop is enabled, open the 2-position minimum outside air damper to introduce the minimum outside air follow quantity as shown. When this loop is disabled, close the minimum outside air damper.

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, 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, close the economizer outside air and relief air dampers, and open the return air damper.

3.2.8.7.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP each have a 1 degree C 2 degrees F deadband.

3.2.8.8 Cold Deck Coil Control

When this loop is enabled, 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, close the cooling coil valve.

3.2.8.9 Zone Temperature Control

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

b. 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). Perform sequencing as shown: Upon a rise in zone temperature above zone temperature setpoint, subject to the zone temperature setpoint deadband as shown, modulate the zone cold deck damper 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, ensure the bypass damper is fully opened and the zone heating valve modulates towards open.

c. For systems with electric resistance heating elements, 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 is proportional-integral (PI) control.

3.2.9.1 HAND-OFF-AUTO Switches

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

3.2.9.1.1 HAND

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

3.2.9.1.2 OFF

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

3.2.9.1.3 AUTO

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

[3.2.9.2 Return Fan Variable Frequency Drive

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

3.2.9.2.1 HAND

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

3.2.9.2.2 OFF

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

3.2.9.2.3 AUTO

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

]3.2.9.3 Occupancy Modes

Obtain Occupancy Mode input from the System Scheduler as specified and shown. Operate the system 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 are subject to Proofs and Safeties. Direct-hardwire interlock safeties to the VFD as shown. Monitor all proofs and safeties and disable all control loops and command the AHU fan off until reset due to failure of any proof or activation of any safety.

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

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 shown on the Points Schedule drawing.

3.2.9.5 System Enable and Loop Enable

3.2.9.5.1 Occupied Mode

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

3.2.9.5.2 Unoccupied Mode

While the building temperature (BLDG-T) is above the low limit setpoint (BLDG-T-LL) disable all control loops and do not run the supply fan. 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), enable the Supply Duct Static Pressure Control[, Return Fan Volume Control][, Preheat Control] loops. Disable the Minimum Outside Air Flow Control, Mixed Air Temperature Control, and Cooling Coil Control loops.

[3.2.9.5.3 Warm Up/Cool Down

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

]3.2.9.6 Fan Capacity Control

3.2.9.6.1 Supply Duct Static Pressure Control

When this loop is enabled, 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, ensure the DDC Hardware capacity modulation output to the VFD is zero percent.

[3.2.9.6.2 Return Fan Volume Control

When this loop is enabled, 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, ensure the output to the VFD is zero percent.

]3.2.9.7 Minimum Outside Air Flow Control

When this loop is enabled, 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, close the minimum outside air damper.

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, 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, close the economizer outside air and relief air dampers, and open the return air damper.

3.2.9.8.3 Economizer Enable Logic

Ensure the economizer is 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. Otherwise the Economizer is OFF. Ensure ECO-HL-SP and ECO-LL-SP each have a 1 degree C 2 degrees F deadband.

3.2.9.9 Cooling Coil Control

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

[3.2.9.10 Preheat Coil Control

When this loop is enabled, 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, close the preheat coil valve.

]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 is proportional-integral (PI) control.

3.3.1.1 Occupancy Modes

3.3.1.1.1 Occupied

Ensure the VAV box DDC Hardware is 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, ensure the VAV box damper is 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 is proportional-integral (PI) control.

3.3.2.1 Occupancy Modes

3.3.2.1.1 Occupied

Ensure the VAV box DDC Hardware is 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

Ensure the VAV box DDC Hardware is 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

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

3.3.2.3 Zone Temperature Control

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

b. In the Unoccupied Mode, ensure the zone temperature setpoint (ZN-T-SP) is at the configured setpoint as shown.

c. 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. Perform sequencing as shown: Upon a rise in zone temperature above zone temperature setpoint (ZN-T-SP), subject to the zone temperature setpoint deadband as shown, adjust the airflow setpointbetween 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, maintain the airflow at a fixed air flow setpoint (with a setting independent of the cooling minimum air flow), and modulate the heating valve towards open or cicle the staged electric resistance heating coil(s) 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 is proportional-integral (PI) control.

3.3.3.1 Occupancy Modes

3.3.3.1.1 Occupied

Ensure the VAV box DDC Hardware is 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

Ensure the VAV box DDC Hardware is 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

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

3.3.3.3 Fan Control

[Run series fans whenever the box is occupied or the Zone Temperature Control loop determines that the box is in heating mode. Prior to starting the fan, close the supply damper. Pause the controller 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, control the supply damper by the Zone Temperature Control loop.][Run parallel fans 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, ensure the zone temperature setpoint (ZN-T-SP) is 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, ensure the zone temperature setpoint (ZN-T-SP)is

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, adjust the airflow setpoint between minimum and maximum based on the difference between zone temperature and zone temperature setpoint as shown. 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 must[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 modulate the heating valve towards open or cycle the staged electric resistance heating coil(s) 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 is proportional-integral (PI) control.

3.3.4.1 Occupancy Modes

3.3.4.1.1 Occupied

Ensure the radiator DDC Hardware is 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

Ensure the radiator DDC Hardware is 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, 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, 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 is 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, 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, control the unit

in accordance with its Occupancy Mode.

3.3.5.2 Occupancy Modes

3.3.5.2.1 Occupied

Ensure the unit heater DDC Hardware is 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

Ensure the unit heater DDC Hardware is 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

Run the unit 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, 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, 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 is 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, energize the heater and run the heater continuously.

3.3.6.1.2 OFF

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

3.3.6.1.3 AUTO

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

3.3.6.2 Occupancy Modes

3.3.6.2.1 Occupied

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

3.3.6.2.2 Unoccupied

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

3.3.6.3 Safeties

Run the heater 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, 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, 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 is 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, 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, control the unit in accordance with its Occupancy Mode.

3.3.7.2 Occupancy Modes

3.3.7.2.1 Occupied

Ensure the unit DDC Hardware is 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

Ensure the unit DDC Hardware is 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

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

Run the unit 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, 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, 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. Monitor the enabled status of all systems served by this system. [If [one][two][___] or more systems served by this system are enabled, enable this system (SYS-ENA), otherwise disable this system][___].

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

Provide hot water pump motor starter with 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 must 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

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.

3.4.1.4 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 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) must be [determined from a linear reset schedule] as shown. When this loop is disabled, close the valve.

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 is proportional-integral (PI) control.

3.4.2.1 System Enable and Loop Enable

a. Monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, enable this

system (SYS-ENA). If no systems served by this system are enabled, disable this system.

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

3.4.2.2 HAND-OFF-AUTO Switch

Provide hot water pump motor starter with an H-O-A switch:

3.4.2.2.1 HAND

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

3.4.2.2.2 OFF

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

3.4.2.2.3 AUTO

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

3.4.2.3 Proofs and Safeties

DDC Hardware must 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

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 shown on the Points Schedule drawing.

3.4.2.4 Boiler Control

When this loop is enabled, turn the boiler on. When this loop is disabled, the boiler is turned off.

3.4.2.5 Hot Water Temperature Control

When this loop is enabled 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) must be [determined from a linear reset schedule] as shown. When this loop is disabled, the valve is 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 is proportional-integral (PI) control.

3.4.3.1 System Enable and Loop Enable

a. Monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, enable this system (SYS-ENA). If all systems served by this system are not enabled, do not enable this system.

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

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

3.4.3.2 Switchover Valve Operation

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 must 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 must 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

Provide Dual-Temperature water pump motor starter with 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 must monitor all proofs and safeties.

3.4.3.4.1 Proofs

None

3.4.3.4.2 Safeties

Direct-hardwire interlock heat exchanger differential pressure switch (HX-P-LL) to the [steam][high temperature hot water] valve.

3.4.3.4.3 DDC Hardware Reset

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 shown on the Points Schedule drawing.

[3.4.3.5 [Heat Exchanger][Mixing] Valve Control

When this loop is enabled 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) must be [determined from a linear reset schedule] as shown. The DDC Hardware must monitor the status of the HX-P-LL safety. When this loop is disabled, close the valve.

]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 is proportional-integral (PI) control.

3.4.4.1 System Enable and Loop Enable:

a. Monitor the enabled status of all systems served by this system. If one or more systems served by this system are enabled, enable this system (SYS-ENA). If all systems served by this system are not enabled, do not enable this system.

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

3.4.4.2 HAND-OFF-AUTO Switch

Provide hot water pump variable frequency drive (VFD) unit with 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. Ensure pump speed is 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, run the pump subject to the Hot Water Pump Start/Stop (HW-PMP-SS) command and ensure pump speed is under control of the DDC system.

3.4.4.3 Proofs and Safeties

DDC Hardware must 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

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 shown on the Points Schedule drawing.

3.4.4.4 Pressure Control

When this loop is enabled 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, ensure the DDC Hardware capacity modulation output to the VFD is zero percent.

-- End of Section --