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**************************************************************************
USACE / NAVFAC / AFCEC              UFGS-23 09 93 (November 2015)
                                    ------------------------------------
Preparing Activity:  USACE          Superseding
                                    UFGS-23 09 23 (May 2011)


                   UNIFIED FACILITIES GUIDE SPECIFICATIONS

            References are in agreement with UMRL dated January 2025
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SECTION TABLE OF CONTENTS

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

SECTION 23 09 93

SEQUENCES OF OPERATION FOR HVAC CONTROL

11/15

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


                            SECTION 23 09 93

               SEQUENCES OF OPERATION FOR HVAC CONTROL
                                 11/15


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

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

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

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


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

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


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

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

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

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

3.1   SEQUENCES OF OPERATION FOR OCCUPANCY SCHEDULING

****
            **NOTE: FYI: Scheduling is normally performed by the
            Monitoring and Control (M&C) software (Section
            25 10 10 UTILITY MONITORING AND CONTROL SYSTEM
            (UMCS) FRONT END AND INTEGRATION. The UMCS (Section
            25 10 10 UTILITY MONITORING AND CONTROL SYSTEM
            (UMCS) FRONT END AND INTEGRATION) Contractor will
            set this up. In the absence of a UMCS or if
            communication with the UMCS is lost, a default
            schedule will be active.**

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

3.1.1   System Mode

Operate air handling units (AHUs) in Occupied, Warm-Up-Cool-Down, or
Unoccupied modes as specified. VAV boxes, Fan Coils, and operate other
terminal equipment in Occupied or Unoccupied modes as specified.
Chillers, boilers, and other sources of heating/cooling for hydronic loads
do not require scheduling; these systems receive requests for
heating/cooling from their loads.

3.1.2   System Scheduler Requirements

****
            **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.**
****

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

****
            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).
****

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

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

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

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

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

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

3.2.1   All-Air Small Package Unitary System

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

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

   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

**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

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

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

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

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

          5) The inclusion of filter pressure switches should
          be coordinated with the local O&M staff. Pressure
          switches may not be desired/needed, particularly if
          filters are replaced on a regular schedule. Edit
          the Points Schedule and Control Schematic as
          required.

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

          7) Absence of fan proof(s) or activation of any
          safety will result in system shutdown. The system
          remains shutdown until manually reset devices are

reset and a manual reset button (RST-BUT), local to
the DDC controller, is pressed. Reset could also be
performed from a workstation (via SNVT) or local
display panel (LDP). It is recommended that you
coordinate the decision with the local O&M staff.
Edit the Control Logic Diagram and Points Schedule
to indicate which reset method is to to be provided
by the Contractor.

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

**9) Smoke control is not addressed in this guide
specification. Smoke control sequence of operation
for each fan system, if beyond the requirements
described, will be developed by the designer, based
on the requirements and parameters of the project.
The designer will account for operation of dampers
and fans for pressurization and manual override of
interlocks to the fire alarm system. All automatic
overrides of normal HVAC control sequences will be
activated through the fire protection and smoke
control interface panel that the designer will
design for the project. With the present control
sequence, in the event of shutdown due to smoke
detector input the system will remain shutdown until
the smoke detector is reset and a separate DDC
reset, as described above, is also used. The Fire
Alarm Panel (FAP) input takes precedence over any
DDC input to force the fan(s) to run.**
****

Install DDC hardware to perform this Sequence of Operation and to provide
SNVT inputs and outputs as specified and shown on the Points Schedule.
Unless otherwise specified, all modulating control 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

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

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

          3) The inclusion of filter pressure switches should
          be coordinated with the local O&M staff. Pressure
          switches may not be desired/needed, particularly if
          filters are replaced on a regular schedule. Edit
          the Points Schedule and Control Schematic as
          required.

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

turning on of the system (due to cleaning staff or
security staff passing through after hours).

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

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

7) Smoke control is not addressed in this guide
specification. Smoke control sequence of operation
for each fan system, if beyond the requirements
described, will be developed by the designer, based
on the requirements and parameters of the project.
The designer will account for operation of dampers
and fans for pressurization and manual override of
interlocks to the fire alarm system. All automatic
overrides of normal HVAC control sequences will be
activated through the fire protection and smoke
control interface panel that the designer will
design for the project. With the present control
sequence, in the event of shutdown due to smoke
detector input the system will remain shutdown until
the smoke detector is reset and a separate DDC
reset, as described above, is also used. The Fire
Alarm Panel (FAP) input takes precedence over any
DDC input to force the fan(s) to run.
****

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

3.2.8.1   HAND-OFF-AUTO Switches

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

3.2.8.1.1   HAND

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

3.2.8.1.2   OFF

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

3.2.8.1.3   AUTO

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

[3.2.8.2   Return Fan Motor Starter

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

3.2.8.2.1   HAND

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

3.2.8.2.2   OFF

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

3.2.8.2.3   AUTO

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

]3.2.8.3   Occupancy Modes

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

3.2.8.4   System Enable and Loop Enable

3.2.8.4.1   Occupied Mode

   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

  ****
              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.

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

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

   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 --