Addendum # 3
Bid Opportunity: 26-7862-RFT - Trillium Public School Office Renovation
Closing Date: Thursday, May 28, 2026 2:00 PM

The following issued by the Board shall form part of the Bid / Proposal Solicitation document. The revisions and additions noted herein along with any attachments shall be read in conjunction with all other related documents. This Addendum shall, take precedence over the previously issued documents where differences occur. Receipt of this addendum must be acknowledged in the Bidding System, bids&tenders.

If you have already submitted a Bid / Proposal, it will be automatically withdrawn as a result of this addendum. You must resubmit the Bid / Proposal acknowledging all addenda and revising your Bid / Proposal to comply with all addenda.

Question 1:

Can you please clarify the abatement notes/scope?
- the notes in the asbestos inventory mention vinyl tile in the f12 and f14 staff washrooms require abatement but the demo drawings show this as a wood floor
- the notes in the asbestos inventory mention a transient pipe, is this referring to the RWL?
- are all windows assumed to have the same sealant and assume all windows will require abatement?

Answer 1:

The floor tiles and mastic in washrooms F12 and F14 were abated in August 2024. Refer to attached letter.
The transient pipe is the existing rainwater leader pipe. The pipe is to be demolished and replaced. Refer also to mechanical drawings.
All sealant at windows is described as containing asbestos and abatement is required where windows are noted to be demolished.

Question 2:

Section Detail 4/A4.2 notes: Provide New poured Concrete Pathway from New Door to Existing Pathway. No detail provided on site plan or on floor plan for the pathway. Please provide the further details and dimensions for the new concrete pathway.

Answer 2:

The requirement for an exterior concrete pathway is hereby removed.

Question 3:

Note R11 on drawing E2.1 requires the electrical contractor to provide a rough-in for the Public Address equipment cabinet consisting of a 1500mm x 1500mm back box, complete with a cover plate and grommetted opening. This translates to a massive 60 x 60 custom enclosure, which is highly unusual for a standard in-wall rough-in and will require costly custom steel fabrication.

Answer 3:

The backbox should be 150mm x 150mm in size and not 1500mm x 1500mm.

Question 4:

Are we restricted to a specific local integrator, or can we consider alternative authorized local system integrators?

Answer 4:

Refer to attached WRDSB BAS System Integration Specifications.

Clarification/Revision Initiated by the Board

- Reference to Division 08 13 16 – Aluminum Doors and Frames, 2.1 Manufacturers - added Windspec as an approved alternate for aluminum frames.

END OF ADDENDUM

P.O #6241122691

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August 8, 2024

Attention: Environmental Officer - WRDSB

Letter of Completion

Location: 79 Laurentian Dr., Kitchener

Re: Asbestos Abatement Type I & II with HEPA

Area: FR W5, E4, F12, F14, F17 & F19

Work Description:

- TYPE 1 & 2 WITH HEPA REMOVAL AND DISPOSAL: Associated with approx. 1,196 sq. ft. of asbestos containing floor tile and associated mastic in the rooms as marked by WRDSB.

All work done in accordance with Ont. Reg. 278/05

Completion Date: August 7, 2024 with 01 AAS & 4 AAW certified staff.

Disposal of Asbestos Waste: Erb St. Dumping & Disposal Unit Waterloo ON

License # 7549-9EZL TL

Regards,

Frank Parronchi

Frank Parronchi,
Owner/President
519 498-0077

WRDSB BAS System Integration Specifications:

Note: Distech BAS SI Partners must incorporate the integration of the WRDSB NIAGARA BAS server as specified in this document. Upgrading or circumventing the functionality of the existing central WRDSB NIAGARA BAS server will not be considered. No unequivocal or irrevocable substitutions of the WRDSB BAS server allowed.

Distech SI Partners:

The fundamental purpose of BAS integration at the WRDSB consist of four primary objectives:

1) to maintain continuity of the Central Command Structure (a.k.a. Global/Local)
2) to allow for future expansion of centrally adjusted network variables/parameters
3) to maximize the administrative efficiency in which we can optimize the functionality and performance of the BAS systems inside 125+ buildings.
4) Maintain Web Security of entire BAS Infrastructure.

Central Command Structure: (two servers during transition period to Niagara-based software)

WRDSB Vista BAS Server

1) Update name to VISTA (formerly EC-TACBAS) on the WRDSB network.
2) is based on the Lonworks (LNS) Based Interface
3) utilizes Remote Network Interfaces (RNI) Ethernet adapters at each site to communicate to the Lonworks network at each site.
4) distributes all network variables via the RNI using the LNS protocol and Loytec NIC-IP to each site.
5) used to administer the TAC Xenta and Lonworks based BAS devices with the Echelon Lonmaker Network configuration tool, Schneider Electric TAC Vista System Plug-in Tool, and Schneider TAC Menta programming software.

WRDSB Niagara BAS Server

1) Update name to NIAGARA (formerly EC-TACBAS-T) on the WRDSB network
2) is based on the Niagara N4-based Distech EC-NET server software to administer the EC-BOS networking devices at each site
3) utilizes Niagara N4-based Distech EC-BOS networking servers complete with adapters at each site to communicate to the BACnet and Lonworks (where applicable) network at each site.
4) distributes all network variables via the Tridium Niagara FOX protocol to each site
5) used to administer the Distech BACnet and Lonworks (where applicable) based BAS devices with the Distech GFX programming/controller configuration and Tridium Niagara WorkBench software
6) utilizes Baudrate Schneider Electric TAC driver software (where applicable) to support the Lon-based TAC Xenta Controllers.

Network Variables: Over 30 network variables (as detailed in Appendix I) are distributed from the central WRDSB BAS server to all 125 sites at varying intervals:

1) for the purpose of zone temperature setpoint adjustment
2) to place lockouts on heating/cooling systems in response to changing seasonal conditions
3) to manage setpoints for night setback heating and cooling modes
4) to manage minimum outside air setpoints for ventilation requirements
5) to adjust the beginning and end of heating season
6) to manage boiler water temperature setpoint outdoor reset parameters
7) to set the morning warmup and night setback offset for boiler water temperature.
8) to place lockouts on ventilation based on building use requirements.
9) to place restrictions on ventilation based on humidity for additional energy savings measures.
10) to distribute humidity information from one of the three WRDSB humidity averaged zones
11) to distribute the central holiday schedule for setback mode operation
12) for Outdoor Lighting Astroclock Control adjustments to sundown and sunset times
13) for the purpose of after-hours alarms and troubleshooting
14) a dashboard is used at the central server to provide a user interface for all the variables and corresponding time/calendar schedules used in the BAS system.
15) a central alarm display is used to capture all incoming BAS alarms from each site.

To be provided by the Distech SI Partner:

A. Hardware Requirements:

1) **LON board inside Distech EC-BOS:** Installed on site, interfaces between site BAS system, Distech Lonworks Controller and Loytec NIC-IP.
2) **Loytec NIC-IP RNI:** Installed at each site, interfaces between site BAS system and WRDSB NIAGARA server via Ethernet and Lonworks networks.
3) **a LON-based Distech controller:** Must be current version. Installed on site, holds the network variables for use by both the WRDSB NIAGARA server and the site BAS system, and also the switching logic between local and global variable selection.
4) **Licensing for LON board, Baudrate Schneider TAC Xenta driver for the Distech EC-BOS:** Allows access to TAC Xenta controllers points, time schedules and alarms for use in the EC-BOS. Licensing confirmation of LON boards, Schneider TAC Xenta Driver, current Distech BAS SI Partner confirmation as a minimum.
5) **Distech BACnet MS/TP based controllers** are accepted for use with all the remaining systems.
6) **WRDSB Ethernet Drops:** Installed on site, to be co-ordinated with WRDSB IT department, fixed IP address to be assigned by IT.
7) **All existing functioning BAS devices** within each of the 125+ WRDSB buildings including but not limited to Lonworks, BACnet controllers as well as other field controls including sensors, valve or damper actuators, VFD drives, chiller systems, unit vents, air handlers, accessories or others, shall remain integrated. Approaches that require the replacement of existing functioning BAS

devices other than the required LAN interfaces for proper integration (EC-BOS / NIC-IP) will not be considered.

B. Software Requirements:

1) **Loytec Lconfig:** Used as setup tool to configure IP address on the Loytec NI-IP for use on WRDSB Ethernet network.
2) **Distech gfx:** Used as a setup tool to program the Distech Lonworks controller to accept the network variables.
3) **Distech Workbench N4:** Used as a setup tool for the Distech EC-BOS

C. Turnover Requirements and Deliverables:

1) **Demonstrate:** full functionality of the integration from the WRDSB server altering the settings on each of the BAS controllers on site.
2) **Database files:** to be backed up and given to WRDSB facilities on USB drive.
   a) **Loytec NIC-IP:** Configuration File
   b) **Distech EC-BOS with Lonworks board and 5-year software updates license:** database file
   c) **Distech Lonworks controller:** controller program file
   d) **Menta**: controller program file for the existing TAC Xenta controllers (supplied by WRDSB to integrator)

3) Security and Serviceability:
   a) Supply username and password.
   b) Source programming software tools with never expiring licenses
   c) Source files and databases for all BAS controllers, networking hardware to be able to network, initialize and replace BAS controllers.
   d) Remote access to school BAS system will not be via VPN or similar method. It will be a managed firewall when available. WRDSB IT firewall and networking rules will need to be followed when integrating the BAS system to the WRDSB NIAGARA BAS Server.
   e) The integrator is required to coordinate with the WRDSB IT services team for SAML integration.

4) Reporting Requirements:

a) Network Transfer Diagram: List in a matrix format, all Distech BAS controllers and associated the network variables, indicating the source and destination for each network variable.
b) Version Control: Maintain a variable for version number for each Distech BAS controller's software with a description of what changes and updates to the controller software were made, initialled, and dated by the programmer in the source code of the controller.

c) Graphical User Interface:

i) **MAIN graphic:** Display all the global network variables, the adjustable local network variables, the adjustable local/global mode switch and the actual network variables in current use, which are actually sent to all the controllers on the local BAS network. Refer to attached sample graphic.

ii) **SYSTEMS graphics (e.g., AC1, AHU1, RTU3):** Indicate the current status of the heating enable, cooling enable, adjustable Holiday Exemption flag, final zone setpoint, Minimum Outside Damper position, Maximum Outside Damper position, Minimum Outside Air Schedule status. Night setback heating and cooling setpoints.

iii) **MAIN graphic:** A link to a notepad file application where an operator can maintain a running day and timestamp in logbook format for any changes/adjustments made to the system, noting any issues that may arise.

D. Implementation:

1. Chain of Data Custody Sequence:

a) Network Variables/Parameters are written to the Distech Lonworks Controller by the WRDSB NIAGARA server via the Loytec NIC-IP adapter.

b) The Distech EC-BOS reads the network variables and then stored on the Lon controller and then distributes them to each controller on the local BAS network for use in its sequence of operations.

c) These network variables are to have a parallel set of local network variables stored in the Distech EC-BOS to be used in the local mode. The local mode when selected will transfer the use of the local network variables from the Distech EC-BOS to each controller on the local BAS network instead of the global network variables written to it by the WRDSB EC-TACBAS server.

d) The local/global mode switch will be adjustable by the WRDSB NIAGARA server and shown on the main page graphic also adjustable by the operator.

2. Data Functionality and Persistence:

a) All network variables/parameters must be backed up into non-volatile RAM so that the network variables are automatically restored after a reboot/cold start.

b) Local/Global Mode Flag to be read/writeable from the WRDSB NIAGARA Server.

c) Critical Alarms reported back to WRDSB NIAGARA server.

d) If site is designated to have an outdoor humidity sensor, the real time value is to be sent back to the WRDSB EC-TACBAS server.

3. Overview

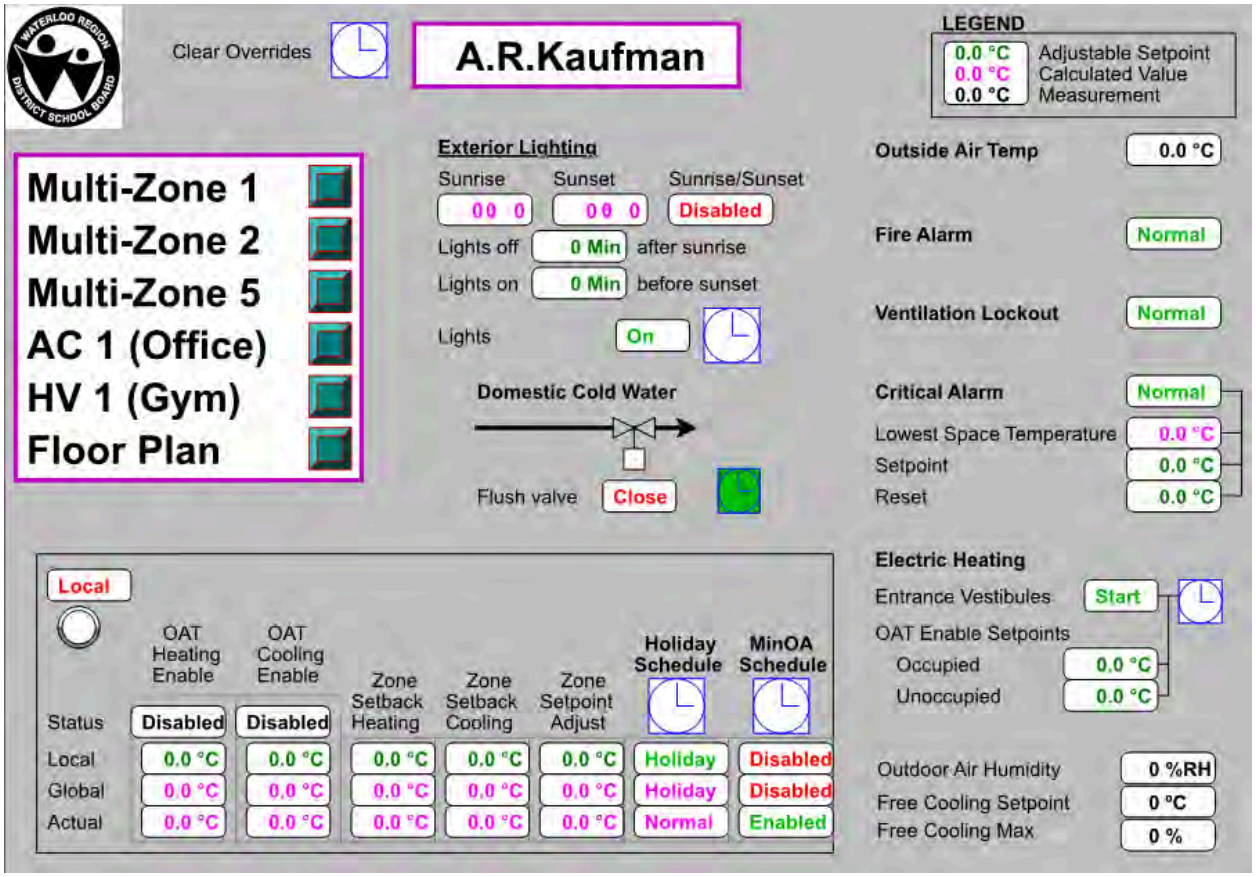
a) Service office within 1 hour of all WRDSB Facilities during school hours and after hours.

b) Written confirmation of Distech SI partnership for WRDSB territory.

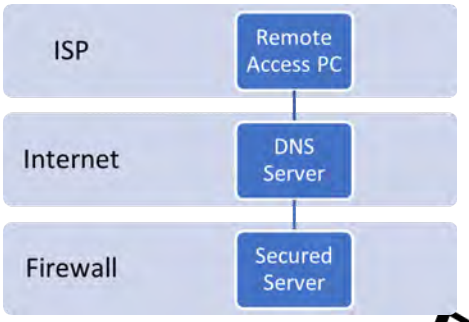
c) Written confirmation of Schneider/TAC Xenta License for NIAGARA Server for WRDSB territory.

Sample I:

Typical **MAIN** graphic for each site representing the expected functionality and data representation of the local/global system:



From Remote Access PC to WRDSB BAS Server to Site – General Architecture



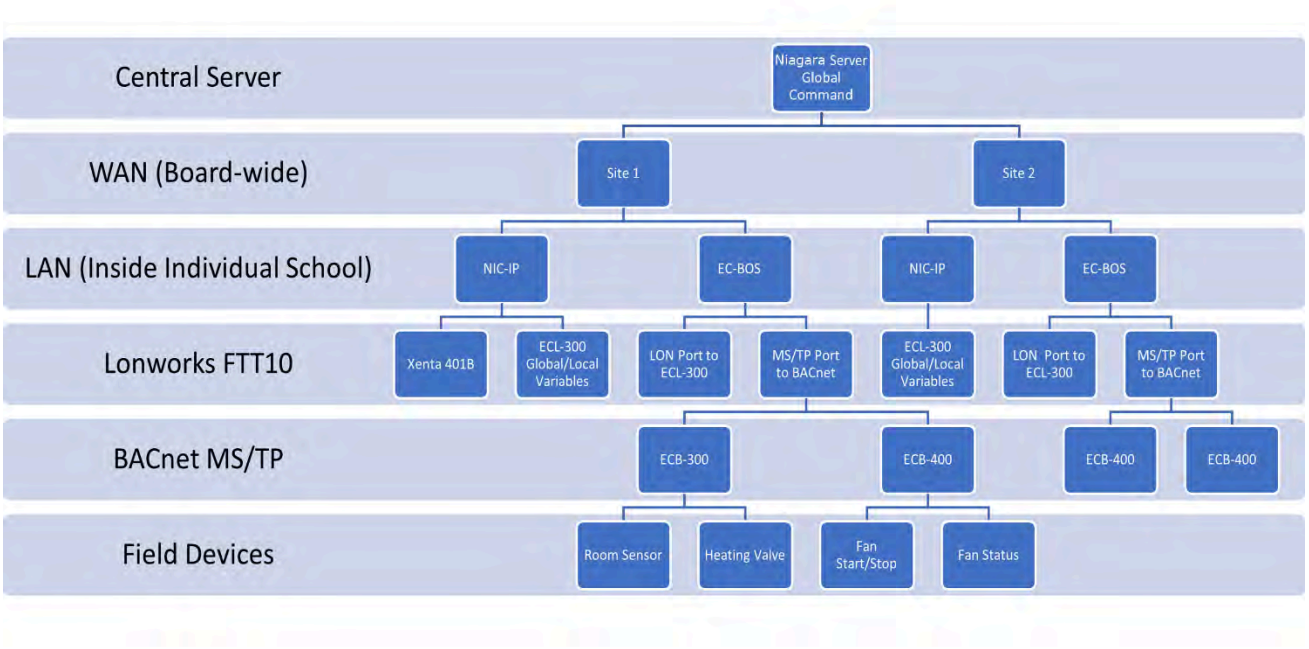
Notes:

- Remote Access Software could consist of Internet Browser, or BAS programming/configuration tools.
- Approved Vendor access
- WRDSB BAS
- WRDSB On-call

REMOTE ACCESS

Firewall

- Network Variables originate from BAS Server.



- Network Variables are received at each site via the NIC-IP and onto the Distech ECL-300 or TAC Xenta 401B Controller and distributed for use at each BAS controller by the EC-BOS.

Appendix I - WRDSB BAS Network Variables:

Globally Distributed Variables from Central BAS Server to Each Site: Each controller on the BAS network on each site will use the following network variables/parameters to integrate into their sequence of operations.

For all Air Handling/Rooftop/Unit Vent Systems:

1) Heating Outside Air Temperature Enable

2) Cooling Outside Air Temperature Enable

3) Zone Temperature Night Setback Heating Temperature Setpoint

4) Zone Temperature Night Setback Cooling Temperature Setpoint

5) Zone Temperature Setpoint Adjust

6) Holiday Scheduling

7) Minimum Outside Air Enable Schedule (Zone 1)

8) Minimum Outside Air Setpoint (Zone 1)

9) Minimum Outside Air Setpoint (Zone 2)

10) Minimum Outside Air Setpoint (Zone 3)

11) Minimum Outside Air Setpoint (Zone 4)

12) Outdoor Air Humidity (Zone 1 calculated average from 3 local sites)

13) Outdoor Air Humidity (Zone 2 calculated average from 3 local sites)

14) Outdoor Air Humidity (Zone 3 calculated average from 3 local sites)

15) Outdoor Air Humidity Maximum Damper Position (Zone 1 Free Cooling Maximum)

16) Outdoor Air Humidity Maximum Damper Position (Zone 2 Free Cooling Maximum)

17) Outdoor Air Humidity Maximum Damper Position (Zone 3 Free Cooling Maximum)

18) Outdoor Air Humidity Maximum Damper Position (Zone 4 Free Cooling Maximum)

19) Free Cooling Maximum Mode (Zone 1)

20) Free Cooling Maximum Mode (Zone 2)

21) Free Cooling Maximum Mode (Zone 3)

22) Free Cooling Maximum Mode (Zone 4)

For Outdoor Lighting Astroclock Control:

1) Lights Off After Sunrise Offset (in minutes) Area 1

2) Lights Off After Sunrise Offset (in minutes) Area 2

3) Lights Off After Sunrise Offset (in minutes) Area 3

4) Lights Off After Sunrise Offset (in minutes) Area 4

5) Lights On Before Sunset (in minutes) Area 1

6) Lights On Before Sunset (in minutes) Area 2

7) Lights On Before Sunset (in minutes) Area 3

8) Lights On Before Sunset (in minutes) Area 4

For Boiler Systems: The 4 hot water setpoint outdoor temperature reset parameters: (sourced from 1 of 4 WRDSB location zones)

Boiler Systems Area 1:

1) Outside Air Temperature 1 **2) Hot Water Temperature High Setpoint**

3) Outside Air Temperature 2 **4) Hot Water Temperature Low Setpoint**

6) Morning Warmup Hot Water Temperature Offset

7) Night Setback Hot Water Temperature Offset

Gas and Boiler Systems Heating Enable/Disable Dates: (4 variables)

8) Heating On Month **9) Heating On Day**

10) Heating Off Month **11) Heating Off Day**

Boiler Systems Area 2:

1) Outside Air Temperature 1 **2) Hot Water Temperature High Setpoint**

3) Outside Air Temperature 2 **4) Hot Water Temperature Low Setpoint**

6) Morning Warmup Hot Water Temperature Offset

7) Night Setback Hot Water Temperature Offset

Gas and Boiler Systems Heating Enable/Disable Dates: (4 variables)

8) Heating On Month **9) Heating On Day**

10) Heating Off Month **11) Heating Off Day**

Boiler Systems Area 3:

1) Outside Air Temperature 1 **2) Hot Water Temperature High Setpoint**

3) Outside Air Temperature 2 **4) Hot Water Temperature Low Setpoint**

6) Morning Warmup Hot Water Temperature Offset

7) Night Setback Hot Water Temperature Offset

Gas and Boiler Heating Enable/Disable Dates: (4 variables)

8) Heating On Month **9) Heating On Day**

10) Heating Off Month **11) Heating Off Day**

Boiler Systems Area 4:

1) Outside Air Temperature 1 **2) Hot Water Temperature High Setpoint**

3) Outside Air Temperature 2 **4) Hot Water Temperature Low Setpoint**

6) Morning Warmup Hot Water Temperature Offset

7) Night Setback Hot Water Temperature Offset

Gas and Boiler Heating Enable/Disable Dates: (4 variables)

8)	**Heating On Month**	**9)**	**Heating On Day**
10)	**Heating Off Month**	**11)**	**Heating Off Day**

<u>Additional Parameters used to calculate final values for distribution from Central Server:</u>

1) **Winter Outside Air Temperature Heating Enable Setpoint**
2) **Summer Outside Air Temperature Heating Enable Setpoint**
3) **Summer Winter Heating Schedule**
4) **Winter Outside Air Temperature Cooling Enable Setpoint**
5) **Summer Outside Air Temperature Cooling Enable Setpoint**
6) **Summer Winter Cooling Enable Schedule**
7) **Normal Night Setback Temperature Heating Enable Setpoint**
8) **Economy Night Setback Temperature Heating Enable Setpoint Calculated**
9) **Comfort/Economy Night Setback Heating Schedule**
10) **Outside Air Low Reset for Economy Night Setback Reset Heating Setpoint**
11) **Night Setback Low for Economy Night Setback Reset Heating Setpoint**
12) **Outdoor Air High Reset for Economy Night Setback Reset Heating Setpoint**
13) **Night Setback High for Economy Night Setback Reset Heating Setpoint**
14) **Normal Night Setback Temperature Cooling Enable Setpoint**
15) **Economy Night Setback Temperature Cooling Enable Setpoint Calculated**
16) **Comfort/Economy Night Setback Cooling Schedule**
17) **Normal Setpoint Adjust**
18) **Economy mode Setpoint Adjust**
19) **Comfort Economy Setpoint Adjust Schedule**
20) **Minimum Outside Air Damper Position Setpoint Schedule to Send Area 1**
21) **Minimum Outside Air Damper Position Setpoint Schedule to Send Area 2**
22) **Minimum Outside Air Damper Position Setpoint Schedule to Send Area 3**
23) **Minimum Outside Air Damper Position Setpoint Schedule to Send Area 4**
24) **Astroclock Lights Off After Sunrise /On Before Sunset Send Schedule Area 1**
25) **Astroclock Lights Off After Sunrise /On Before Sunset Send Schedule Area 2**
26) **Astroclock Lights Off After Sunrise /On Before Sunset Send Schedule Area 3**
27) **Astroclock Lights Off After Sunrise /On Before Sunset Send Schedule Area 4**
28) **Heating Systems Send Schedule Area 1**

29) **Heating Systems Send Schedule Area 2**
30) **Heating Systems Send Schedule Area 3**
31) **Heating Systems Send Schedule Area 4**

Locally Distributed Network Variables Distributed between Master controller and each Controller within each site These Network Variables are centrally managed and distributed to each controller. A local copy of these variables are maintained and are adjustable when the site is set to local mode operation.

1) **Outside Air Temperature**
2) **Local Holiday Schedule**
3) **Fire Alarm Status**
4) **Ventilation Lockout Status**
5) **Heating Outside Air Temperature Enable/Disable**
6) **Cooling Outside Air Temperature Enable/Disable**
7) **Zone Temperature Night Setback Heating Temperature Setpoint**
8) **Zone Temperature Night Setback Cooling Temperature Setpoint**
9 **Zone Temperature Setpoint Adjust**
10) **Holiday Scheduling**
11) **Minimum Outside Air Enable Schedule**

Additional calculated parameters used in the sequence of operations and shared across the site network:

1) Minimum Zone Temperature per Controller

2) Maximum Zone Temperature per Controller

3) Minimum Zone Temperature per Site (data is aggregated across all the controllers and concentrated at the single master controller that triggers the low temperature alarm contacts)

4) Maximum Zone Temperature per Site (data is aggregated across all the controllers and concentrated at the single master controller)

WRDSB BAS Master Sequence of Operations

Version 1.0q Updated: January 30, 2025

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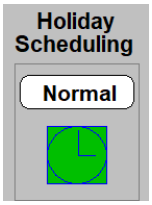
1. Integration Requirements

General Sequence of Global and Local Operation

1.1. Holiday Schedule

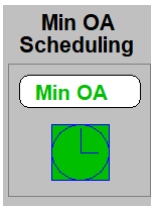
A calendar based schedule that is user adjustable at a global (board wide) or local (site specific) level. Typical entries include the standard board and statutory holidays that apply to the school board: New Year's Day, Christmas Day, Boxing Day, Christmas Holidays, Canada Day, etc. and are pre-defined at the front end Server Dashboard.



1.2. Global Ventilation Schedule

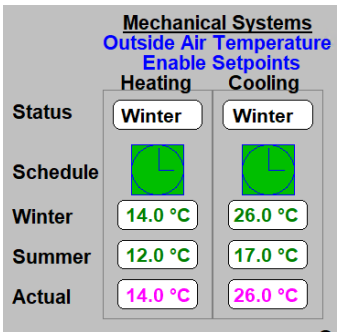
A time of day schedule that is user adjustable at global (board wide) or local (site specific) level. Typical entries include: 7:00 a.m. to 4:00 p.m. Monday to Friday.

Outside of this schedule all outdoor air dampers are maintained (spring return / fail) closed when Global Ventilation is disabled.



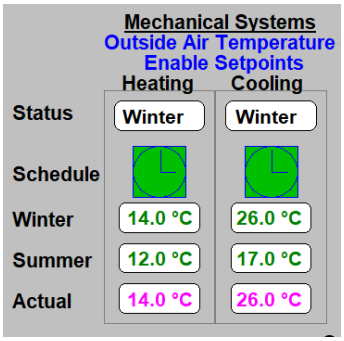
1.3. Cooling Enabled Mode

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule. Typical default values are: 18 °C from May to September, except 21 °C from June to August.



1.4. Heating Enabled Mode

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.



1.5. Free Cooling Setpoint Calculation

The average outdoor air relative humidity is sent from the Niagara Server to the Global Input for all schools / Ed Centre where the Free Cooling Setpoint is calculated. Free cool is enabled when OAT < minimum (23.5°C, 29.4°C - **Φ**/7.43) where **Φ** is the average relative humidity in %RH.

The free cooling signal is 100% when the OAT is more than 2°C below the free cooling setpoint. The free cooling signal decreases towards zero linearly as the outdoor air temperature increases from 2 °C below the free cooling setpoint to 0 % at the setpoint. This free cooling signal is used in each mixed air damper controller as the maximum the outdoor air dampers can open. Minimum outdoor air damper position signal may exceed the free cooling signal. The free cooling signal is still subject to the mixed damper safeties that would keep minimum position during occupied mode. Also the free cooling signal will be at a lower priority than the CO_2 demand ventilation (where applicable) up to 40% outside damper position.

Partial free cooling (25 %OA) is permitted when the outdoor air temperature is below 23 °C the with outdoor air relative humidity at 40 %RH and below. Full free cooling (100 %OA) is permitted when the outdoor air temperature is below 21.5 °C with the outdoor air relative humidity at 43.5 %RH and below.

Free cooling is linearly restricted from 100 %OA to 0 %OA as the outdoor air temperature increases above 21.5 °C or the the outdoor air relative humidity increases above as per this reset table:

Freecooling Threshold Calc	Maximum Damper Position
min(21.5, 29.4 - OARH/7.43) |	100 %OA
min(23, 29.4 - OARH/7.43) |	0 %OA

The free cooling threshold (in °C) is calculated based on the outdoor relative humidity according to the following formula.
Free cooling threshold = MIN(23, 29.4 - **OARH** / 7.43)

The free cooling signal is limited by the following formula:
Maximum Free Cooling Damper Position = MIN(100, MAX(0, (((**OAT** - MIN(23.5, 29.4 - **OARH** / 7.43)) / (-2)) *100))))

Where the outside air temperature (**OAT in °C**) and the outdoor air relative humidity (**OARH in %RH**) is used to calculate the maximum position the outdoor air damper may open for free cooling. Note the use of MIN (minimum) and MAX (maximum) functions to limit the output of the formula to between 25 and 100 %.

This formula results in the following Damper Position (%OA) table:

Maximum Free Cooling Damper Position Table based on OAT and OARH values are rounded to nearest 5 and 10 %RH)

OAT (° C) ↓	**40**	**50**	**60**	**70**	**← (%RH)**
23	25	0	0	0	
22.5	50	0	0	0	
22	75	35	0	0	
21.5	100	60	0	0	
20.5	100	100	40	0	
19.5	100	100	90	25	
18.5	100	100	100	75	

The intermediate steps are shown in the following sample table for reference:

Free Cooling Threshold Calc - Sample Table

Parameters

Outdoor Air Temperature OAT (°C)	Outdoor Air Relative Humidity (%RH)	Formula For Free Cooling Setpoint (°C)	Difference (between OAT and Formula in °C)	Maximum Free Cooling Signal (%OA)
25.5	43.5	23.5	2	0
24.5	43.5	23.5	1	0
23.5	43.5	23.5	0	0
23	43.5	23.5	-0.5	25
22.5	43.5	23.5	-1	50
22	43.5	23.5	-1.5	75
21.5	43.5	23.5	-2	100
20.5	43.5	23.5	-3	100
19.5	43.5	23.5	-4	100
18.5	43.5	23.5	-5	100

17.5	43.5	23.5	-6	100
16.5	43.5	23.5	-7	100
16	43.5	23.5	-7.5	100

1.6. Sample Calculations Tables:

1.6.1. Humidity-Limited Free Cooling

The table in Appendix 'A' serve to illustrate the net result of the Free Cooling Setpoint Calculation formula for a given dataset of Outdoor Air Humidity (average relative humidity in %RH) and Outdoor Air Temperatures (OAT in °C)

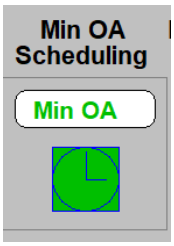
1.6.2. Outside Air Temperature Limit Free Cooling

This table in Appendix 'B' serve to illustrate the net result of the Outdoor Low Limit Calculation formula for a given dataset of Outdoor Air Temperatures (OAT in °C)

The Outdoor Low Limit Calculation is used to restrict the maximum outdoor damper position when the outdoor air temperature is too cold for the proper operation of the mechanical equipment as an additional preventative level of freeze protection.

1.7. Minimum Outdoor Air Enable Time Schedule:

A set of time schedules, one for each of the 4 school board areas are configured (typically from 7:00 a.m. to 4:00 p.m., to send an enable flag to each site to allow outside air mixing dampers to open to minimum position, economizer operation (for required cooling demand) or return air CO_2 (for required ventilation demand).

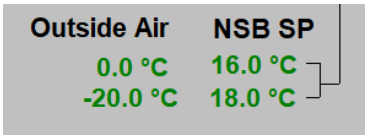


1.8. Minimum Outdoor Air Mixing Damper Position Setpoint:

A set of Minimum Outdoor Air Position, one for each of the the 4 school board areas are configured to send to each of the sites to send the outdoor air mixing dampers to open to minimum position when the Minimum Outdoor Air Enable Time Schedule is enabled and there are no additional demands for cooling or ventilation are called. Set point to be 5% or minimum permitted by ASHRAE 6.2 Table 6-2 Area Outdoor Air Rate - Educational Facilities at 0.06, 0.12 and 0.18 cfm/ft2 - for occupiable space - no corridors, utility spaces, etc

1.9. Night Setback Heating Setpoint:

Reset from outdoor air temperature. The setpoint is used as a threshold to determine if the system is to be automatically brought out of an idle night setback mode and into an active heating mode.



1.10. BAS Designations:

System Point Nomenclature

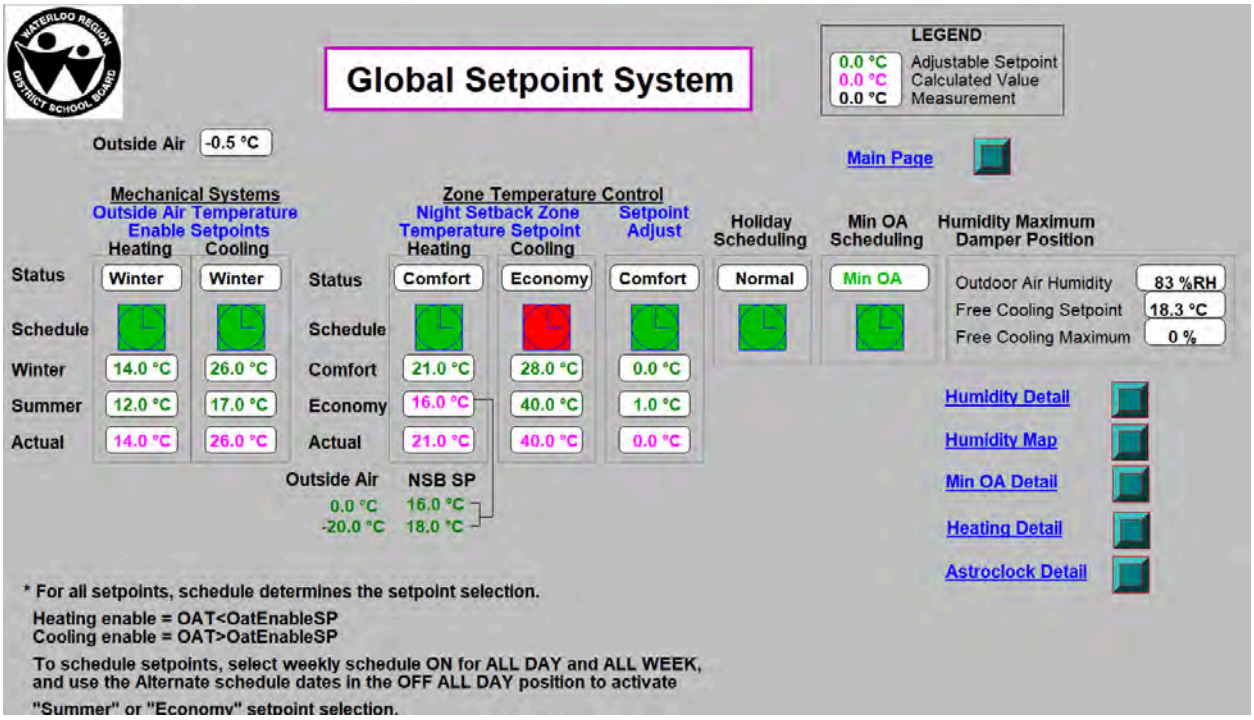
Each of the system components are to be named or referenced in the BAS system as per the following table. Consultants/ designers / contractors are to use the same reference designation in schedules / specifications and equipment labels to ensure conformity with control operations, future warranty and maintenance and associated work order systems.

COMPONENT DESCRIPTION	BAS DESIGNATION
Air Handling Unit	AHU
Boiler	B
Bypass Damper	BD
Bypass Box (Dump Box)	BB
Cabinet Heater	CH
Chiller	CHR
Condensing Units / Heat Pump Unit	CU
Cooling Tower	CT
Domestic Hot Water Heater	DHW
Ductless Split	DS
Electric Heater	EH
Energy Recovery Ventilator	ERV
Exhaust Fan	EF
Fan Coil	FC
Gas Fired Heat Pump	GHP
Heat Pumps	HP
Variable Refrigerant Flow Unit	VRF
Heat Recovery Ventilator	HRV
Heating & Ventilation Unit	HV
Heating Ventilation & Air Conditioning Unit	HVAC
Make Up Air Unit	MUA
Multizone Unit	MZ
Outside Lighting	Outside Lighting
Package Cooling Only Unit	AC
Packaged Terminal Air Conditioner	PTAC
Pump or Circulator (Domestic, Storm/Sanitary, Chilled, Heating Water)	P
Radiator	RAD
Radiant Floor Heat	RFH
Radiant Panel	RP
Reheat Coil	RHC
Return Fan	RF
Supply Fan	SF
Unit Heater	UH
Unit Ventilator	UV
Variable Air Volume Damper	VAV
Variable Volume Temperature Damper	VVT
Water Main Auto Flush	WM Auto Flush

2. Definitions:

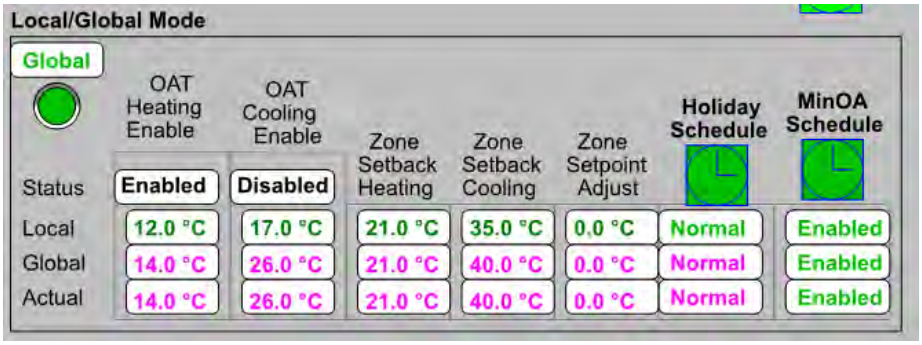
2.1. Global Functions:

A set of setpoints and schedules managed by the high level operator from a central server dashboard.



2.2. Local Functions:

A set of setpoints and schedules managed by the high level operator from a site specific dashboard.graphic.



2.3. Local Mode of Operation:

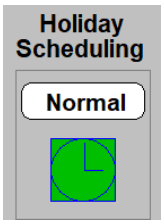
When the local/global flag is set to Local mode, the global setpoints and schedules are ignored and the local setpoints and schedules are used to determine the various enable/disable modes of operation.

2.4. Global Mode of Operation:

When the local/global flag is set to Global mode, the local setpoints and schedules are ignored and the global setpoints and schedules are used to determine the various enable/disable modes of operation.

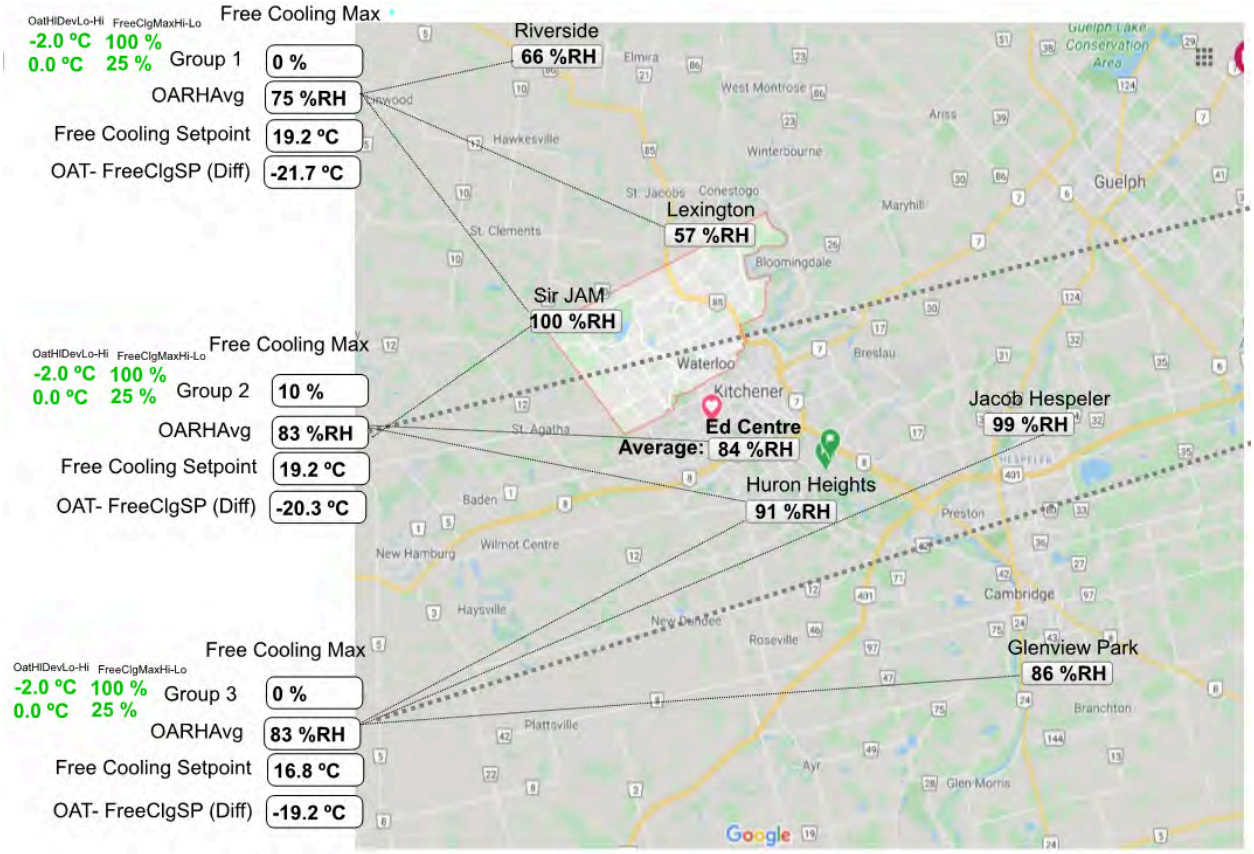
2.5. Server Based Holiday Scheduling

A central master holiday calendar-based schedule overrides the regular time schedule of each system unless exempted on a system-by-system basis.



2.6. Server based Humidity:

Each school is placed into one of three humidity zones when the nearest three outdoor humidity sensors are averaged at the server level and then distributed to each of the three humidity zones.

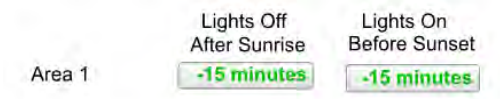


2.7. Server based Heating Reset Setpoints:

Each school with hot water systems will have a set of outdoor heating reset parameters sent to it based on one of four area locations. These reset parameters are managed by a high level operator from a central server dashboard.

2.8. Server based Astroclock:

Each school with outdoor lighting will have a set of lighting offset parameters sent to it based on one of four area locations.These parameters will provide an offset (in minutes, typically -15 minutes) to direct the lights off after sunrise and the lights on before sunset.

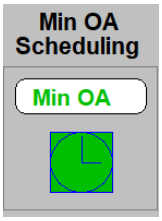


2.9. Fire Alarm Sequence of Operation:

On a fire alarm condition, an alarm is generated at the BAS and all supply fans stop (except exhaust fans stay under automatic control) in order to alleviate smoke movement. This is not intended as a safety interlock - only to avoid unnecessary alarms at the BAS. Unless otherwise directed by the local authority having jurisdiction.

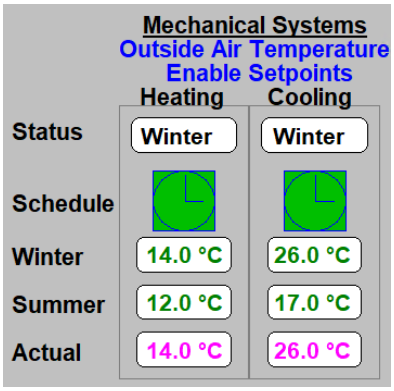
2.10. Server based Minimum Outdoor Air Damper Position Setpoint:

Each school will have an minimum outdoor damper position setpoint sent to it based on one of four area locations. These parameters are managed by a high level operator from a central server dashboard.



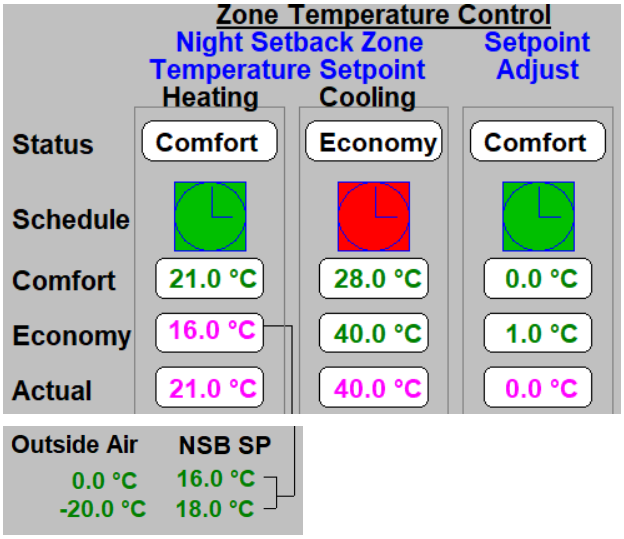
2.11. Server based Mechanical Systems Outdoor Air Temperature Enable Setpoints:

Each school will have a threshold for enabling mechanical heating or cooling based on outdoor air temperature thresholds. These parameters are managed by a high level operator from a central server dashboard.



2.12. Server based Zone Temperature Control for Night Setback Heating Setpoints and Setpoint Adjusts:

Each school will have a threshold for enabling the night setback mode when the calculated lowest zone for a particular system falls below threshold. Also the default setpoint can be adjusted to allow for a higher setpoint for the cooling season and holidays. These parameters are managed by a high level operator from a central server dashboard



2.13. **Local System-Based Default Room (Heating) Setpoint**

Each air handler and rooftop HVAC system will have an independently adjustable setpoint (in °C) from the system graphic for the user with custodial-level security privileges.

2.14. **Local System-Based Time Schedule**

Each exhaust fan, outdoor lighting, air handler and rooftop HVAC system will have an independently adjustable time schedule (with hours of the day repeating weekly) from the system graphic for the user with at least custodial-level security privileges and above.

2.15. **Outdoor Air Temperature**

Each site will have its own dedicated outdoor air temperature sensor wired to an input of a controller. The controller will share the outdoor air temperature with all the other controllers on site for use in various functions which include determining temperature setpoints and enable/disable thresholds for equipment operation.

2.16. **Optimized Start Program**

Each HVAC system with a time of day schedule will utilize the controller's internal Optimized Start Program to determine the actual start time for the Morning Warm-Up Mode of operation. The controller's Optimized Start Program parameters and inputs are to be configured as follows:

Inputs:

1) Outdoor Air Temperature
2) Room Temperature or Lowest Zone Temperature (where applicable)
3) Local System-Based Time Schedule
4) Local System-Based Default Room Heating Setpoint
5) Local System-Based Unoccupied Room Heating Setpoint (Distech)

Parameters:

1) Maximum Start time offset 105 minutes
2) Maximum Temperature offset 2 °C

The Optimized Start Program functions with an algorithm that keeps an internal history of the inputs and its calculated start times that is self-adjusting based on the past performance of the system's Morning Warm up Mode.

2.17. **Morning Warmup Mode:**

An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled at full capacity and the cooling is disabled.

2.18. **Rooftop Heating Stage Sequencing:**

Room Controller PID, (generates a signal based on the room temperature and room setpoint from 0 %Clg to 100 %Clg), typically stage 1 heating is enabled at 25 %Clg PID signal and disabled at 50 %Clg PID signal and

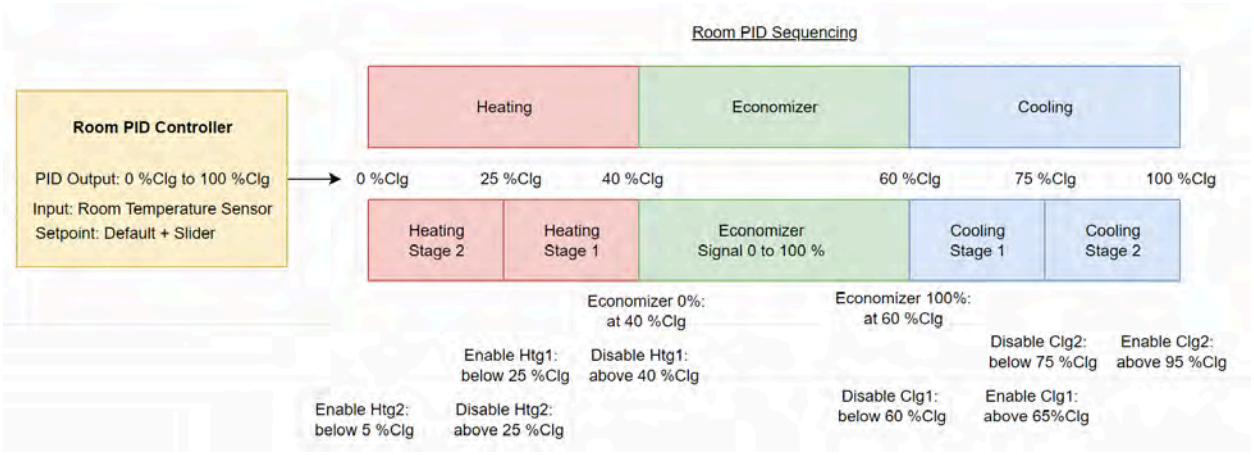
stage 2 heating is enabled at 5 %Clg PID signal and disabled at 25 %Clg PID signal.

2.19. Rooftop Economizer Sequencing:

The economizer signal goes from 0 % to 100 % as the Room Controller PID goes from 40 %Clg to 60 %Clg.

2.20. Rooftop Mechanical DX Cooling Stage Sequencing:

Room Controller PID, typically
stage 1 cooling is enabled at 75 %Clg PID signal and disabled at 60 %Clg PID signal and
stage 2 cooling is enabled at 95 %Clg PID signal and disabled at 60 %Clg PID signal).



3. Equipment Specific Sequence of Operations:

3.1. VVT HVAC Rooftop Unit Sequence of Operations:

3.1.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0% outdoor air position, heating is disabled and cooling is disabled. The VVT bypass damper is in the 100 % open position. The zone dampers are in the 50 % open position. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.1.2. Software Freeze-stat Shutdown Mode:

The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 3 minutes, restored above 5 °C after 3 minutes, and auto reset after 5 minute delay).

3.1.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.
The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.1.3.1. (Idle State)

The supply fan is off, the return fan is off (where applicable) power exhaust fan is off (where applicable), the Global Ventilation Schedule is disabled, the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. The bypass damper is in the 100 % open position. The zone dampers are in the 50 % open position.

3.1.3.2. (Heating State)

System cycles on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
The VVT HVAC unit supply air static pressure setpoint is increased by 20 %. Bypass damper(s) and associated zone damper(s) modulate to obtain setpoint.
Unoccupied Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C Outdoor Air Temperature or lower and 18.0 °C at -20.0 °C Outdoor Air Temperature or lower (each adjustable)
Mechanical Cooling: Disabled
Free Cooling: Disabled

Global Ventilation Schedule: Disabled

3.1.3.3. (Push Button Override State)
The default room temperature setpoint remains unchanged.
Idle state of the unoccupied mode is exited if the override pushbutton is pressed, (for a minimum of 2 seconds) at any room sensor.
The associated system will switch to the Occupied Mode for 2 hours (adjustable).
Free Cooling: Disabled
Mechanical Cooling: Enabled
Global Ventilation: Enabled
The system returns to idle state in the unoccupied mode after the 2 hours after the pushbutton trigger has elapsed.

3.1.4. Morning Warmup Mode:
An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled at full capacity and the cooling is disabled.
The VVT bypass damper(s) starts in the 100 % open position. The zone dampers start in the 50 % open position.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.
Free Cooling: Disabled
Mechanical Cooling: Disabled
Global Ventilation Schedule: Disabled
The system exits Morning Warmup Mode and continues into occupied mode when the lowest indoor zone temperature is warmed up to default room temperature setpoint.

3.1.5. Occupied Mode:
Time of day schedule, which starts the HVAC unit(s) along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
HVAC unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled temperature setpoint nominal 22.5 °C +/-1.0 °C
Room mechanical cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Global Ventilation Schedule: Enabled

3.1.6. Standby Occupancy Mode:
Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.
Minimum outdoor air is set to zero when the global ventilation schedule is off.
Fan operation: Supply fan and return fan (where applicable) runs only on a call from heating or cooling.
Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.1.7. Zone Damper:
The room sensor modulates the zone damper between minimum and maximum settings to maintain (Occupied, Standby, or Unoccupied) Mode temperatures.
The setpoint is adjustable at the sensor.
The control is reverse acting when the supply temperature is more than 1 °C above room temperature and direct acting when the supply air temperature is more than 1 °C below room temperature.
If the system mode is different from the zone mode (e.g. system is in heating mode but zone requires cooling), the zone damper closes to a reduced minimum position to minimize overheating/overcooling.
A minimum of 5 minutes to changeover between Heating to Cooling Modes is required.

3.1.8. System Heating/Cooling Decision Process:
3.1.8.1. Enable Criteria:
The system mode is determined by the number of zones that deviate by 1.2 °C from their respective zone heating/cooling setpoints. The number of zones is “weighted” by the deviation from setpoint. If the total number of zones requesting heating

outnumber (or are equal to) the total number of zones requesting cooling the system will go to Heating Enabled Mode and in reverse for Cooling Enabled Enabled Mode.
Once in Heating Enabled Mode or Cooling Enabled Mode, the reference zone becomes the zone of greatest call. The system will lock-in the selected mode until all zones are satisfied. If all zones are not satisfied within 20 minutes (60 minutes if all zones are in the same mode) the system will “unlock” and enable Forced Ventilation Mode.
The outdoor air temperature determines the heating or cooling priority.

3.1.8.2. Heating Enabled Mode
In Heating Enabled Mode, the highest priority zone calling for heating is given first priority. If there is any zone calling for cooling, this is given second priority.

3.1.8.3. Cooling Enabled Mode
In the Cooling Enabled Mode, the highest priority zone calling for cooling is given first priority. If any zone is calling for heating, this is given second priority.

3.1.8.4. Default Ventilation Mode
If there is neither a call for cooling or heating, the system is returned to the Ventilation Sequence

3.1.8.5. Forced Ventilation Mode
Every 20 minutes if the system is not satisfied (and 60 minutes if all zones are in the same mode) the system is switched to ventilation mode for 5 minutes

3.1.9. Ventilation Lockout (Sequence):
When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.1.10. Heating Sequence:

3.1.10.1. Outdoor Air Temperature used to determine Heating Enable Mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.1.10.2. Default Setpoint:
When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.1.10.3. Call for Heating:
Mechanical heating is used until the heating calls (from room controller PID or Night Setback thresholds) are satisfied.
If the total number of zones requesting heating outnumber (or are equal to) the total number of zones requesting cooling, the system will go into Heating Mode.
For Modulating Burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the rooftop unit to 17.0 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the rooftop unit to 35 °C).
Hydronic
For Heating Valve, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (below 2 Volts) opens the heating valve.
Radiation Zone
Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be substituted as the first stage of heating.
Supplemental Electric Space Heating
Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.1.11. Cooling Sequence:

3.1.11.1. Outdoor Air temperature used to determine cooling enable mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.1.11.2. Default Cooling Setpoint:
When the cooling enable mode is active, the default room temperature setpoint is raised by 3 °C.

3.1.11.3. Call for Cooling:
When Free Cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the cooling calls (from room controller PID) are satisfied.
If the total number of zones requesting cooling outnumber the total number of zones requesting heating, the system will go into cooling mode.

3.1.12. Reference Zone Sequence:

Once in heating or cooling mode, the reference zone becomes the zone with the greatest call. The system mode will lock-in in the selected mode until all zones are satisfied.

3.1.13. Forced Vent Sequence

When Global Ventilation Schedule is Enabled: If any zone is deprived of ventilation air for more than 20 minutes, the system will unlock and go into Forced Ventilation Mode for 5 minutes, and then reselect the required mode of operation.

3.1.14. Slave Zones:

Zones designated as slave zones without cooling (typically corridors) cannot request heating or cooling, but will utilise healing when available. Cooling is not available and locked out for slave no-cooling zones. Zones designated as slave zones with cooling (typically a retrofitted work room off a classroom) cannot request heating or cooling but will utilize healing or cooling when available. Slave zones with cooling are to be minimized.

3.1.15. System Heating Control:

Stage 1 and Stage 2 heating are controlled from the reference zone as follows:

Reference Zone Call for Heating	
Stage 1 On	1.0 °C
Stage 1 Off	0.5 °C
Stage 2 On	1.5 °C
Stage 2 Off	1.0 °C

Modulation: Heating is modulated (where applicable).

3.1.16. System Cooling Control:

Stage 1 and Stage 2 cooling are controlled from the reference zone as follows:

Reference Zone Call for Cooling	
Stage 1 On	1.2 °C
Stage 1 Off	0.5 °C
Stage 2 On	1.5 °C
Stage 2 Off	0.9 °C

Modulation: Cooling is modulated (where applicable).

3.1.17. Bypass Operation:

The supply air static pressure sensor modulates the bypass damper between minimum and maximum settings to maintain supply static pressure setpoint. Reduce the supply air static pressure setpoint during both Default and Forced Ventilation modes, typically 10 Pa for acoustic noise reduction. During Unoccupied Mode setback, increase supply air static pressure setpoint, typically 120 % of regular setpoint.

3.1.18. Ventilation Sequence:

The system operates in ventilation mode (no heating or cooling) under the following conditions: No zones are calling for heating or cooling.System is switching between heating and cooling (the system operates in ventilation mode for 5 minutes).One or more zones have been operating at a reduced minimum position for more than 20 minutes (system operates in Forced Ventilation Mode for 5 minutes).

3.1.19. Economizer Operation (and CO2 Demand Control Ventilation) :

3.1.19.1. During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.

3.1.19.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 5 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.

3.1.19.3. For HVAC units with power exhaust, the exhaust fan runs when the outdoor air damper is more than 50 % open.

3.1.19.4. During morning warm-up, the outdoor air minimum position is set to zero.

3.1.19.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.1.19.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint Sequence of Operation, the mixing dampers will be set to the minimum outdoor air threshold unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).

3.1.19.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40% outdoor air as the CO_2 level increases from 1100 ppm (1000 ppm to 1200 ppm over a ramped 15 minute period).

3.1.19.8. CO_2 levels are automatically logged at 10 minute intervals (adjustable).

3.1.20. Additional Rooms Partition Switch

Any additional room(s) (ie. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read “No Cooling when Partition is Open to Gym”.

3.1.21. Limits and Safeties:

3.1.21.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature. At -15°C or below, outdoor air temperature, the maximum outdoor air damper position will be 0% open and at 10°C outdoor air temperature, the maximum outdoor air damper position will be 100%.

3.1.21.2. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively high supply air temperature. At 30°C outdoor air temperature and above, the maximum outdoor air damper position will be 0% open and at 10°C outdoor air temperature, the maximum outdoor air damper position will be 100%

3.1.21.3. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11 °C). In applications where the mixed air sensor is located after the DX cooling coil, the setpoint is reduced (to typically 5 °C) when DX cooling is enabled.

3.1.21.4. The duct mounted supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60°C , and enable below 50°C, for stage 2: disable above 55°C and enable below 45°C) and a low limit for each stage of cooling (for stage 1: disable DX1 below 5°C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13°C enable DX2).

3.1.21.5. The supply air temperature sensor acts as a software freezestat (triggered below 1 °C for 1 minute, restored above 5 °C for 1 minute), auto reset after 5 minute delay.

3.1.21.6. The supply fan has a delay-off time of 90 seconds.

3.1.21.7. The DX cooling has a minimum-off time of 5 minutes.

3.1.21.8. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint or when fan is off.

3.1.21.9. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint or when the fan is off.

3.1.21.10. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.1.21.11. During Default and or Forced Ventilation Modes, if the supply air temperature falls below 15 °C for more than two minutes, stage 1 heating will turn on until supply air temperature exceeds 25 °C (to improve comfort).

3.1.21.12. The default zone setpoint is increased by 3°C when mechanical cooling is enabled (providing heating is disabled). The standard mechanical cooling setpoint will be limited to a (minimum of 23.5 °C - adjustable).

3.1.21.13. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode.

3.1.21.14. Minimum outdoor air is provided when enabled by the Global Ventilation Schedule.

3.1.21.15. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 to 40 % as the reading increases from 1000 ppm to 1200 ppm.

3.1.21.16. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.1.21.17. During Occupied Mode, and the outdoor air is above -1°C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3°C with a +2°C deadband.

3.1.21.18. Minimum outdoor air is set to zero when the Global Ventilation Schedule is off.

3.1.22. Alarms:

An alarm will be generated upon the following conditions:

3.1.22.1. Fan status does not match the start/stop signal.

3.1.22.2. Mixed air temperature too high alarm, (triggered above 50 °C and restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7°C). Low mixed air temperature alarm set to lower thresholds when Mixed Air Temperature sensor is installed after the DX/cooling coil.

3.1.22.3. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C).

3.1.22.4. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38°C and restored above 36°C) for cooling systems.

3.1.22.5. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.1.22.6. Supply air static pressure too low alarm (below 5 Pa and restored below 15 Pa) or too high alarm (above 240 Pa and restored below 230 Pa), with a 30 minute delay.

3.1.22.7. Weekly fan runtime limit exceeded.

3.1.22.8. Return air CO_2 too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 and restored above 300 ppm) with a 15 minute delay.

3.1.22.9. Software freezestat tripped.

3.2. Single Zone HVAC Rooftop Sequence of Operations: (with Heating, Ventilating and Mechanical Cooling)

3.2.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.2.2. Freeze-stat Shutdown Mode(s):

3.2.2.1. Software

The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 1 minute delay, restored above 5 °C after 5 minute delay).

3.2.2.2. Hard-Wired

In addition BAS monitors status of the duct mounted hard wired freeze-stat (provided by others, where applicable) that shuts down the AHU fan(s) and spring closes the outside air damper(s) if the air temperature leaving the heating coil falls below the freeze-stat setpoint.

3.2.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.
The system will cycle between Idle State, Heating State and Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.2.3.1. (Idle State)

The supply fan is off, the return fan is off (where applicable), the power exhaust fan is off (where applicable), the Global Ventilation Schedule is disabled, the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled.

3.2.3.2. (Heating State)

System cycles on a call for unoccupied heating (which is triggered by the System Minimum Zone Temperature falling below the Unoccupied Heating Room Setpoint).
Supply fan cycles on, associated exhaust or return fan cycles on (where applicable).
A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the rooftop unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the rooftop unit to 35 °C).
Unoccupied Heating Room Temperature Setpoint nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C Outdoor Air Temperature or lower and 18.0 °C at -20.0 °C Outdoor Air Temperature or lower (each adjustable)
Mechanical Cooling: Disabled
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.2.3.3. (Push Button Override State)

The default room temperature setpoint remains unchanged.
Idle state of the unoccupied mode is exited if the override pushbutton is pressed, (for a minimum of 2 seconds) at any room sensor.
The associated system will switch to the Occupied Mode for 2 hours (adjustable).
Free Cooling: Disabled
Mechanical Cooling: Enabled
Global Ventilation: Enabled
The system returns to idle state in the unoccupied mode after the 2 hours after the pushbutton trigger has elapsed.

3.2.4. Morning Warmup Mode:

An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled at full capacity and the cooling is disabled.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.
Free Cooling: Disabled
Mechanical Cooling: Disabled
Global Ventilation Schedule: Disabled
The system exits Morning Warm Up Mode and continues into occupied mode when the lowest indoor zone temperature is warmed up to default room temperature setpoint.

3.2.5. Occupied Mode:

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
HVAC unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room Heating Temperature Setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled Temperature Setpoint nominal 22.5 °C +/-1.0 °C
Room Mechanical Cooling Temperature Setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Global Ventilation Schedule: Enabled

3.2.6. Standby Occupancy Mode:

Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.
Minimum outdoor air is set to zero (with future provision to adjust) when the global ventilation schedule is off.
Fan operation: Supply fan and return fan (where applicable) runs only on a call from heating or cooling.
Ventilation normally set to zero (with a future provision to adjust).
Room Heating Temperature Setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling Temperature Setpoint nominal 24.5 °C +/- 1.0°C (adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.2.7. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.2.8. Heating Sequence:

3.2.8.1. Outdoor Air Temperature used to determine Heating Enable Mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the Outdoor Air Temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.2.8.2. Default Setpoint:

When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.2.8.3. Call for Heating:

Mechanical heating is used until the heating calls (from room controller PID, typically stage 1 heating is enabled at 25 %Clg PID signal and disabled at 50 %Clg PID signal and stage 2 heating is enabled at 5 %Clg PID signal and disabled at 50 %Clg PID signal or Night Setback thresholds) are satisfied.
For Modulating Burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the rooftop unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the rooftop unit to 35 °C).
The room temperature sensor regulates heating output to maintain the occupied heating setpoint. Local setpoint adjustment is provided. The power exhaust fan or return fan (if applicable) cycles based on the rooftop economizer position.

Hydronic

For Heating Valve, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (below 2 Volts) opens the heating valve.

Radiation Zone

Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be substituted as the first stage of heating.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.2.9. Cooling Sequence:

3.2.9.1. Outdoor Air Temperature used to determine cooling enable mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the Outdoor Air Temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule. Typical default values are: 18°C from May to September and 21°C from June to August.

3.2.9.2. Default Setpoint:

When the cooling enable mode is active, the default room temperature setpoint is raised by 3 °C.

3.2.9.3. Call for Cooling:

When Free Cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the cooling calls (from room controller PID) are satisfied.

The room temperature sensor also modulates the mixing dampers (for free cooling) to maintain the occupied free cooling setpoint.

3.2.10. Ventilation Sequence:

The system operates in ventilation mode (no heating or cooling) under the following conditions: System is switching between heating and cooling

3.2.11. Economizer Operation (and CO_2 Demand Control Ventilation) :

3.2.11.1. During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the mixing dampers will be modulated open on a call for cooling to provide 'free' cooling.

3.2.11.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 5 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.

3.2.11.3. For HVAC units with power exhaust, the exhaust fan runs when the outdoor air damper is more than 50% open.

3.2.11.4. During morning warm-up, the outdoor air minimum position is set to zero.

3.2.11.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.2.11.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint Sequence of Operation, the mixing dampers will be set to the minimum outdoor air threshold unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).

3.2.11.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1100 ppm (1000 ppm to 1200 ppm over a ramped 15 minute period).

3.2.11.8. Additional Rooms Partition Switch

Any additional room(s) (ie. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read "No Cooling when Partition is Open to Gym".

3.2.12. Limits and Safeties

3.2.12.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature during startup. At -20 °C outdoor air temperature, and below, the maximum outdoor air damper position will be 0 % open and at 10 °C outdoor air temperature the maximum outdoor air damper position will be 100 %.

3.2.12.2. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11 °C). In applications where the mixed air sensor is located after the DX cooling coil, the setpoint is reduced (to typically 5 °C) when DX cooling is enabled.

3.2.12.3. The supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60 °C , and enable below 50 °C, for stage 2: disable above 55 °C and enable below 45 °C) and a low limit for each stage of cooling (for stage 1: disable DX1 below 5 °C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13 °C enable DX2).

3.2.12.4. The supply air temperature sensor acts as a software freezestat (trigger above 1 °C and restore above 5 °C) after 1 minute delay, auto reset after 5 minute delay).

3.2.12.5. The supply fan has a delay-off time of 90 seconds.

3.2.12.6. The DX cooling has a minimum-off time of 5 minutes.

3.2.12.7. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 2 °C below Cooling Enable setpoint) or when fan is off.

3.2.12.8. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.2.12.9. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.2.12.10. Minimum outdoor air is provided when enabled by the global minimum outdoor air time schedule. The minimum outdoor air is adjustable from the graphic and is typically a default of 10 % open outdoor damper position.

3.2.12.11. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 % to 40 % as the reading increases from 1000 ppm to 1200 ppm.

3.2.12.12. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.2.12.13. During Occupied Mode, and the outdoor air is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.2.12.14. The default room temperature setpoint is increased by 2 °C when mechanical cooling is enabled (providing heating is disabled). The standard mechanical cooling setpoint will be limited to a minimum of 23.5 °C.

3.2.12.15. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to standby mode of operation.

3.2.12.16. Minimum outdoor air is set to zero when the global ventilation schedule is off (standby occupancy).

3.2.12.17. Discretionary Fire Alarm Shutdown Mode to be enabled on the fire alarm status.

3.2.13. Alarms:

An alarm will be generated upon the following conditions:

3.2.13.1. Fan status does not match the start/stop signal.

3.2.13.2. Mixed air temperature too high alarm, (triggered above 50 °C and restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7 °C). Low mixed air temperature alarm set to lower thresholds when Mixed Air Temperature sensor is installed after the DX/cooling coil.

3.2.13.3. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C).

3.2.13.4. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored above 36 °C) for cooling systems.

3.2.13.5. Space temperature too low alarm (triggered above 14 °C and restored above 16°C).

3.2.13.6. Weekly fan runtime limit exceeded.

3.2.13.7. Return air CO_2 too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 and restored above 300 ppm) with a 15 minute delay.

3.2.13.8. Software freezestat tripped.

3.3. Gym HV Rooftop Sequence of Operations: (with Heating and Ventilating Only)

3.3.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HV unit functions are auto restored on relay signal from the fire alarm panel reset.

3.3.2. Software Freezestat Shutdown Mode:

The duct/unit mounted supply air temperature sensor acts as a software freezestat (triggered below 1°C after 3 minutes, restored above 5°C after 3 minutes, and auto reset after 5 minute delay).

3.3.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.
The system will cycle between Idle State, Heating State Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.3.3.1. (Idle State)

The supply fan is off, the return fan is off (where applicable), the power exhaust fan is off (where applicable), Global Ventilation Schedule is disabled, the outdoor air mixing dampers are in the 0 % outdoor air position, the heating is disabled.

3.3.3.2. (Heating State)

System cycles on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C OAT or lower and 18.0 °C at -20.0 °C OAT or lower (each adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.3.3.3. (Push Button Override State)

If the override pushbutton is pressed, at any gym sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation enabled.

3.3.4. Morning Warmup Mode:

An optimized start, based on the time of day schedule, outdoor air temperature and the indoor zone temperature is provided for heating.
The global Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position and heating is enabled at full capacity.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest space temperature up to occupancy setpoint.

3.3.5. Occupied Mode:

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.

HV unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room heating temperature nominal: 21.5 °C +/- 1.0 °C (adjustable, 2.0 °C for gyms)
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the HV unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the HV unit to 35 °C).
Room Free Cooling Enabled temperature nominal 22.0 °C +/-1.0 °C (adjustable, 2.0 °C for gyms)

3.3.6. Standby Occupancy Mode:
Time of day schedule starts the unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday. Minimum Outdoor Air is set to zero when the Global Ventilation Schedule is off. Supply fan and return fan (where applicable) runs only on a call from heating. Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature nominal: 21.5 °C +/- 1.0°C (adjustable, 2.0 °C for gyms)
Room Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.3.7. Ventilation Lockout (Sequence):
When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.3.8. Heating Sequence
3.3.8.1. Outdoor Air Temperature used to determine Heating Enabled Mode:
A set of thresholds that are user adjustable at a Global (board wide) or Local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.
3.3.8.2. Default Setpoint:
When the Heating Mode is active, the default room temperature setpoint remains unchanged.
3.3.8.3. Call for Heating:
Heating is used until the heating calls (from room controller PID or unoccupied heating thresholds) are satisfied.
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the rooftop unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the rooftop unit to 35 °C).
The room temperature sensor regulates heating output to maintain the occupied heating setpoint. Local setpoint adjustment is provided. The power exhaust fan or relief fan (if applicable) cycles based on the rooftop economizer position..

3.3.9. Economizer Operation (and CO_2 Demand Control Ventilation):
3.3.9.1. During Occupied Mode, economizer operation will be substituted for mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.
3.3.9.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 5 % outdoor air, which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.
3.3.9.3. For HV units with power exhaust, the exhaust fan runs when the outdoor air damper is more than 50 % open.
3.3.9.4. During morning warm-up, the outdoor air minimum position is set to zero.
3.3.9.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.
3.3.9.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint Sequence of Operation, the mixing dampers will be set to the minimum outdoor air threshold unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).
3.3.9.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1100 ppm (1000 ppm to 1200 ppm over a ramped 15 minute period).

3.3.10. Gym Partition Switch
The gym partition position switch (where applicable for multiple gyms) indicates whether the dividing wall is open or closed. If the wall is open, the two rooftop units (where applicable) control to an average room temperature setpoint. If the wall is closed, the two rooftop units (where applicable) operate autonomously. Gym partition switch to be provided by the Building Automation Contractor.

3.3.11. Additional Rooms Partition Switch
Any additional room(s) (ie. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving

the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read “No Cooling when Partition is Open to Gym”.

3.3.12. Limits and Safeties

3.3.12.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature during startup. At -20 °C outdoor air temperature, and below, the maximum outdoor air damper position will be 0 % open and at 10 °C outdoor air temperature the maximum outdoor air damper position will be 100 %.

3.3.12.2. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11°C).

3.3.12.3. The supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60 °C , and enable below 50 °C, for stage 2: disable above 55 °C and enable below 45 °C) and a low limit for each stage of cooling (for stage 1: disable DX1 below 5 °C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13 °C enable DX2).

3.3.12.4. The duct mounted supply air temperature sensor acts as a software freezestat (triggered below 1 °C, restored above 5 °C), 1 minute delay, auto reset after 5 minute delay).

3.3.12.5. The supply fan has a delay-off time of 90 seconds.

3.3.12.6. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 18 °C) or when the fan is off.

3.3.12.7. Stage 1 gas heating (where applicable for staged heating) has a minimum run time of 3 minutes.

3.3.12.8. Minimum outdoor air is provided when enabled by the global minimum outdoor air time schedule. The minimum outdoor air is adjustable from the graphic and is typically a default of 10 % open outdoor damper position.

3.3.12.9. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air damper position from 0 % to 40 % as the return air carbon dioxide reading increases from 1000 ppm to 1200 ppm.

3.3.12.10. During Occupied Mode, and the outdoor air is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.3.12.11. The default space setpoint is increased by 2 °C when free cooling is enabled (providing heating is disabled). The standard cooling setpoint will be limited to a minimum of 23.5°C.

3.3.12.12. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to standby mode of operation.

3.3.12.13. Minimum outdoor air is set to zero when the global ventilation schedule is off (standby occupancy).

3.3.12.14. Discretionary Fire Alarm Shutdown Mode to be enabled on the fire alarm status.

3.3.13. Alarms:

An alarm will be generated upon any of the following conditions:

3.3.13.1. Fan status does not match the start/stop signal.

3.3.13.2. Mixed air temperature too high alarm (triggered above 50 °C restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7 °C). Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C)

3.3.13.3. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored below 36 °C) for cooling systems.

3.3.13.4. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.3.13.5. Weekly fan runtime limit exceeded.

3.3.13.6. Return air CO_2 too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 ppm and restored above 300 ppm).

3.3.13.7. Software freezestat tripped

3.4. HRV and ERV Unit Sequence of Operations:

3.4.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the exhaust fan is off, all the outside air dampers spring closed to the 0 % outdoor air position. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HRV / ERV unit functions are auto restored on the relay signal from the fire alarm panel reset.

3.4.2. Software Freezestat Shutdown Mode:

The duct/unit mounted supply air temperature sensor downstream of the wheel/core acts as a software freezestat (triggered below 1 °C for 3 minutes, restored above 5 °C for 3 minutes, and auto reset after 5 minute delay).

3.4.3. Unoccupied Mode:

The exhaust fan is off, the supply fan is off, and the intake and exhaust dampers are spring return.

3.4.4. Morning Warmup Mode:

Not applicable. Same as Unoccupied mode.

3.4.5. Occupied Mode:
The supply and exhaust fans run continuously when any associated rooftop unit is operating in Occupied Mode, the economizers are less than 30 % outside air dampers position and the Global Ventilation Schedule is on. Fan status indication is from the current sensing device(s). Fan operation: The supply fan (except for freeze protection) and exhaust fan run continuously.

3.4.6. Econo Mode:
3.4.7. The Econo Mode will be enabled when the outside air damper position across all associated HVAC / HV units are equal to or greater than 30 % for more than 15 minutes, indicating that the HVAC / HV units are in free cooling mode. The HRV / ERV will be disabled on a call from BAS and all associated dampers shall spring closed.
3.4.8. If any associated outside air damper position across all associated HVAC units are equal to or less than 30 % for more than 15 minutes the Econo Mode will be disabled and HRV / ERV unit operation will resume.
3.4.9. The Econo Mode will not be applicable to HRV / ERV units serving washrooms.

3.4.10. Standby Occupancy Mode:
Not applicable. Same as Unoccupied Mode.

3.4.11. Ventilation Lockout (Sequence):
When the ventilation lockout switch, usually located in the Custodial Office, is engaged, supply and exhaust fans stop, all dampers spring close, and the system switches to Unoccupied Mode of operation.

3.4.12. Limits and Safeties
3.4.12.1. Defrost control provided by the ERV/HRV manufacturer. The internal frost controls (supply fan stops, exhaust fan defrosts the core).
3.4.12.2. Systems that have electric or hydronic reheat are to be avoided.
3.4.12.3. The supply air sensor acts as a software freezestat (triggered below 1 °C for 3 minutes, restored above 5 °C for 3 minutes, and auto reset after 5 minute delay).
3.4.12.4. The supply and exhaust fans stop on a fire alarm condition.
3.4.12.5. If the mixed air damper position exceeds 30 % outdoor air on all associated HVAC units, the HRV/ERV supply and exhaust fans stop. Not applicable to units that serve washrooms.
3.4.12.6. If deemed required, ERV/HRV's exhaust fans may need to continue to run for systems serving washroom exhausts when the system is not in occupied mode. (Revisit issue with consultants)

3.4.13. Alarms:
An alarm will be generated upon the following conditions:
3.4.13.1. After 15 minute delay (adjustable), supply fan status does not match the start/stop signal.
3.4.13.2. After 15 minute delay (adjustable), exhaust fan status does not match the start/stop signal.
3.4.13.3. Supply air temperature too high alarm (triggered above 35 °C and restored below 33 °C) or too low alarm (triggered 1 °C and restored below 3 °C)
3.4.13.4. Return air temperature too high alarm (triggered above 40 °C and restored below 38 °C) or too low alarm (triggered above 14 °C and restored below 15 °C)
3.4.13.5. Exhaust air temperature too high alarm (triggered above 40 °C and restored below 38 °C) or too low alarm (triggered below -1 °C and restored above 1 °C).
3.4.13.6. Weekly fan runtime limit exceeded.

3.5. Unit Ventilators Sequence of Operations:

3.5.1. Discretionary Fire Alarm Shutdown Mode:
The supply fan is off, and associated exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, the hydronic heating remains in its current state and the cooling is off (where applicable).
The face and bypass damper are open to the face of the coil(s).
The associated relief dampers (where applicable) are in the closed position.
This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal UV unit functions are auto restored on relay signal from the fire alarm panel reset.

3.5.2. Software Freezestat Shutdown Mode:
The duct/unit mounted supply air temperature sensor acts as a software freezestat (triggered below 1 °C after 3 minutes, restored above 5 °C after 3 minutes, and auto reset after 5 minute delay).

3.5.3. Unoccupied Mode
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State and Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.5.3.1. (Idle State)

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday. The supply fan is off, associated exhaust fan is off (where applicable), the Global Ventilation Mode is off, the outdoor air mixing dampers are in the 0% outdoor air position, the heating is off and the cooling is off (where applicable). The face and damper is in the face position. The associated relief dampers (where applicable) are closed.

3.5.3.2. (Heating State)

System cycles on a call for unoccupied heating. The face and bypass dampers go to face position to obtain room temperature setpoint.

Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C Outdoor Air Temperature or lower and 18.0 °C at -20.0 °C Outdoor Air Temperature or lower (each adjustable).

Mechanical Cooling: Disabled (where applicable)

Free Cooling: Disabled

Global Ventilation Schedule: Disabled

3.5.3.3. (Push Button Override State)

If the override pushbutton is pressed, at any room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation and cooling enabled.

3.5.4. Morning Warmup Mode:

An optimized start routine for heating advances the system start time when morning warm-up is required. An optimized start, based on the time of day schedule, outdoor air temperature and the room temperature is provided for heating.The global ventilation schedule is off.

The supply fan is on, the associated exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, the heating at full capacity is on and the cooling is off (where applicable).

The heat pump (where applicable) is the first stage of heat but when it is in defrost mode or when the outdoor air is too cold, then hydronic heat is used to provide heat.

The face and bypass damper(s) start in the face position. The associated exhaust dampers (where applicable) start in the closed position.

The optimized start program is to begin up to 105 minutes before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.

3.5.5. Occupied Mode

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.

The Global Ventilation Schedule is on.

Fan status indication is from the current sensing device(s).

Fan operation: The supply fan and return fan (where applicable) run continuously.

Heating temperature nominal: 21.5 °C +/- 1.0 °C (adjustable)

Mechanical cooling temperature nominal 24.5 °C +/- 1.0 °C (adjustable)

Free cooling enabled temperature nominal 22.5 °C +/-1.0 °C

Global Ventilation Schedule: Enabled

3.5.6. Standby Occupancy Mode:

Time of day schedule starts the unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.

Minimum Outdoor Air is set to zero when the Global Ventilation Schedule is off.

Fan operation: Supply fan and associated exhaust fan (where applicable) runs only on a call from heating or cooling only.

Ventilation normally set to zero (with a future provision to adjust).

Heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)

Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable) (where applicable)

Free Cooling: Disabled

Global Ventilation Schedule: Disabled

3.5.7. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.5.8. Heating:

3.5.8.1. Outdoor Air Temperature used to determine Heating Enable Mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.

Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.5.8.2. Default Setpoint:

When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.5.8.3. Call for Heating:

The room temperature sensor modulates the face & bypass damper with heat pump or hydronic heating to maintain the temperature setpoint.

The heat pump is the first stage of heat (nominally to 5 °C outdoor air temperature) but when it is in defrost mode or when the outdoor air is too cold, then hydronic heat is used to provide heat.

When in heating mode, the mixing dampers are in minimum position and cooling is off.

Mechanical heating is used until the heating calls (from room controller PID or Unoccupied Heating thresholds) are satisfied.

The room temperature sensor regulates heating output to maintain the occupied heating setpoint. Local setpoint adjustment is provided.

Where there is a zone served by radiation, the radiation valve opens (where applicable) as the first stage of heating.

Hydronic

For Heating Valve, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (below 2 Volts) opens the heating valve.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.5.9. Cooling Sequence:

3.5.9.1. Outdoor Air Temperature used to determine cooling enable mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the Outdoor Air Temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.5.9.2. Default Setpoint:

When the cooling enable mode is active, the default room temperature setpoint is raised by 2 °C.

3.5.9.3. Call for Cooling:

When free cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the cooling calls (from room controller PID) are satisfied.

The room temperature sensor also modulates the mixing dampers (for free cooling) to maintain the occupied free cooling setpoint Heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)

The heat pump is the first stage of heat but when it is in defrost mode or when the outdoor air is too cold, then hydronic heat is used to provide heat.

Cooling setpoint is maintained at 3 °C higher than the default room setpoint and will not go below 23.5 °C.

Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)

The room temperature sensor modulates the mixing dampers in sequence with DX cooling (where applicable) and face and bypass dampers in face position, to maintain the cooling temperature setpoint.

When mechanical cooling is on, heating is off.

3.5.10. Economizer Operation (and CO2 Demand Control Ventilation) :

3.5.10.1. During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this Free Cooling Setpoint the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.

3.5.10.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 5 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.

3.5.10.3. For units with an associated exhaust, the exhaust fan runs when the outdoor air damper is more than 50 % open.

3.5.10.4. During morning warm-up, the outdoor air minimum position is set to zero.

3.5.10.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.5.10.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint Sequence of Operation, the mixing dampers will be set to the minimum outdoor air threshold unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).

3.5.10.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1100 ppm (1000 ppm to 1200 ppm over a ramped 15 minute period).

3.5.11. Limits and Safeties

3.5.11.1. If the outside air temperature exceeds the Global Free Cooling Setpoint, the mixing dampers return to the minimum position.

3.5.11.2. Mixed air damper minimum position control is provided when the Global Ventilation Schedule is on (initially 10 %OA).

3.5.11.3. The exhaust air damper (if applicable) opens from 0 to 100 % as the outdoor air damper opens from minimum position to maximum position.

3.5.11.4. The minimum outdoor damper position is ramped from minimum to 40 % as the room sensor CO_2 increased from 1000 ppm to 1200 ppm over a 15 minute period.

3.5.11.5. The fan must be running before the mixing dampers, face and bypass dampers, heat pump (if applicable) and DX cooling will operate.

3.5.11.6. The economizer is limited to 60 % because of the intake louver dimensions. (if applicable)

3.5.11.7. The supply air sensor acts as a low limit to ensure temperature does not fall below setpoint (initially 16 °C, reset to 13 °C on a call for free cooling).

3.5.11.8. A software freezestat on the supply air temperature shuts the fan down and closes the outdoor air damper when the supply air temperature is below 3 °C for 30 seconds (resets above 6 °C with 5 minute delay before restart).

3.5.11.9. If the hard-wired freezestat trips, the fan shuts down, the heat pump shuts down (if applicable), the outside air damper closes, the heating valve opens and an alarm is generated at the BAS.

3.5.11.10. DX cooling is disabled when the outside air temperature falls below the global mechanical cooling disable setpoint (initially 14 °C).(where applicable)

3.5.11.11. DX cooling has a minimum off time of 5 minutes.(where applicable)

3.5.11.12. DX cooling has a supply air temperature low limit (disabled below 6 °C and enabled above 12 °C). (where applicable)

3.5.11.13. The face & bypass damper is in the face position and the heating valve is closed when DX cooling is operating, (where applicable)

3.5.11.14. The heat pump is disabled when the outdoor air temperature is below 5 °C and hydronic heat is used (where applicable)

3.5.11.15. Defrost mode is determined by a sudden drop in supply air temperature while the heat pump is heating.

3.5.11.16. 16) Heating is disabled when the outside air temperature is above the global heating disable setpoint (typically 16 °C).

3.5.11.17. 17) The heating valve min. position increases from 0 to 60% as the outside air temperature falls from 3 °C to -3 °C to reduce the likelihood of coil freeze.

3.5.12. Alarms

An alarm will be generated upon any of the following conditions:

3.5.12.1. Fan status does not match the fan start/stop signal.

3.5.12.2. Room temperature is too high (triggered above 36 °C and restored below 34 °C) or too low (triggered below 14 °C and restored above 15 °C).

3.5.12.3. Supply air temperature too high (triggered above 65 °C and restored below 60 °C) or too low (triggered below 8 °C and restored above 10 °C).

3.5.12.4. Software or hard-wired freezestat tripped.

3.5.12.5. Fan runtime exceeded weekly runtime setpoint.

3.5.12.6. CO_2 level too high (triggered above 1700 ppm and restored below 1650 ppm) or too low (triggered below 250 ppm and restored above 300 ppm).

3.5.12.7. Heat pump defrost mode is on more than 40 % of the time.

3.6. Air Handlers Sequence of Operations:

3.6.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal AHUt functions are auto restored on relay signal from the fire alarm panel reset.

3.6.2. Freeze-stat Shutdown Mode(s):

3.6.2.1. Software

The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 3 minutes, restored above 5 °C after 3 minutes, and auto reset after 5 minute delay).

3.6.2.2. Hard-Wired

BAS monitors the status of the duct mounted hard wired freeze-stat (provided by others, where applicable) that shuts down the AHU fan(s) and spring closes the outside air damper(s) if the air temperature leaving the heating coil falls below the freeze-stat setpoint.

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3.6.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.
The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands from each state are satisfied.

3.6.3.1. (Idle State)

The supply fan is off, associated return fan is off (where applicable), the Global Ventilation Mode is disabled, the outdoor air mixing dampers are in the 0 % outdoor air position, the gas heating is disabled (where applicable) and the cooling is disabled (where applicable).

For hydronic heated AHU, when outdoor air temperature is below 3 °C, the heating valve (where applicable) modulates to maintain a supply air plenum temperature of 15 °C. When outdoor air temperature is 3 °C or above, the heating valve (where applicable) is closed to the coil. The heating coil circulating pump (where applicable) runs continuously in Winter Mode.

3.6.3.2. (Heating State)

System cycles on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C OAT or lower and 18.0 °C at -20.0 °C OAT or lower (each adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.6.3.3. Push Button Override State)

If the override pushbutton is pressed, at any associated room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation enabled.

3.6.4. Morning Warmup Mode:

An optimized start, based on the time of day schedule, outdoor air temperature and the indoor zone temperature is provided for heating.
The global Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position and heating is enabled at full capacity.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest space temperature up to occupancy setpoint.

3.6.5. Occupied Mode:

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
Air handler fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room heating temperature nominal: 21.5 °C +/- 1.0 °C (adjustable)
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the HV unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the HV unit to 35 °C).
Room Free Cooling Enabled temperature setpoint nominal 22.5 °C +/-1.0 °C
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)

3.6.6. Standby Occupancy Mode:

Time of day schedule starts the unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday. Minimum Outdoor Air is set to zero when the Global Ventilation Schedule is off. Supply fan and return fan (where applicable) runs only on a call from heating. Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature nominal: 21.5 °C +/- 1.0°C
Room Free Cooling: Disabled
Mechanical Cooling: Enabled
Global Ventilation Schedule: Disabled

3.6.7. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.6.8. Heating Sequence:

3.6.8.1. Outdoor Air Temperature used to determine Heating Enabled Mode:

A set of thresholds that are user adjustable at a Global (board wide) or Local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.6.8.2. Default Setpoint:

When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.6.8.3. Call for Heating:

Heating is used until the heating calls (from room controller PID or unoccupied heating thresholds) are satisfied.
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the unit to 35 °C).

For hydronic heated AHUs, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (2 Volts) opens the heating valve. (Note:The heating valve is reverse acting to the controller output signal and is to fail safe open)
The heating coil circulating pump (where applicable) runs continuously in Winter Mode.
The room temperature sensor with the lowest temperature regulates heating output to maintain the ~~occupied~~ heating setpoint. Local setpoint adjustment is provided. The power exhaust fan or relief fan (if applicable) cycles based on the rooftop economizer position.
Where there is a zone served by radiation, the radiation valve opens (where applicable) as the first stage of heating.

3.6.9. Mechanical Cooling Sequence:

3.6.9.1. Default Setpoint:
When the Mechanical Cooling Mode is active, the default room temperature cooling setpoint is 24.5 °C +/- 1°C and will not go below 23.5 °C.

3.6.9.2. Call for Cooling:
Mechanical cooling will be used until the cooling calls (from room controller PID) are satisfied.

3.6.9.3. Chilled Water Cooling Sequence:

3.6.9.4. Unoccupied Mode
The cooling coil valve is closed. There can be no unoccupied cooling.

3.7. Occupied Mode
The cooling coil valve modulates open when there is chilled water in the CW Mains.

3.7.1. Free Cooling Sequence:

3.7.1.1. Outdoor Air Temperature used to determine cooling enable mode:
(Free cooling enabled) A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.7.1.2. Default Setpoint:
When the cooling enable mode is active, the default room temperature setpoint is raised by 2 °C higher than the heating setpoint and will not go below 23.5 ℃

3.7.1.3. Call for Cooling:
When free cooling is available, and a demand for cooling is in place, free cooling will be used, until the cooling calls (from room controller PID) are satisfied.
The room temperature sensor also modulates the mixing dampers (for free cooling) to maintain the occupied free cooling setpoint.

3.7.2. Economizer Operation (and CO_2 Demand Control Ventilation):
During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.

3.7.2.1. Minimum Outdoor Air Damper Position
A typical value for minimum outdoor air damper position is 5 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate. Minimum outdoor air damper position signal may exceed the economizer signal.

3.7.2.2. Economizer Operation
The outdoor air mixing dampers will be set to the minimum outdoor air position unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO2 demand controlled ventilation reset).
If Free Cooling is enabled during Occupied Mode, economizer operation will be substituted for first stage mechanical cooling, the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.
For air handling units with power exhaust (where applicable), the exhaust fan runs when the outdoor air damper is more than 50 % open
During morning warm-up, the outdoor air minimum position is set to zero.
During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.
Each return air duct-mounted or space mounted CO2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO2 level increases from 1000 ppm to 1200 ppm over a ramped 15 minute period). CO2 levels are automatically logged at 10 minute intervals
Each return air duct-mounted or space mounted CO2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO2 level increases from 1000 ppm to 1200 ppm over a ramped 15 minute period). CO2 levels are automatically logged at 10 minute intervals

3.7.3. Additional Rooms Partition Switch

Any additional room(s) (i.e. Music Rooms) that are separated by a partition wall from a space where cooling is not allowed, will disable mechanical cooling for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read “No Cooling when Partition is Open to Gym”.

3.7.4. Limits and Safeties

3.7.4.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature during startup. At -20 °C outdoor air temperature, and below, the maximum outdoor air damper position will be 0 % open and at 10 °C outdoor air temperature the maximum outdoor air damper position will be 100 %.

3.7.4.2. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11 °C). In applications where the mixed air sensor is located after the DX cooling coil, the setpoint is reduced (to typically 5 °C) when DX cooling is enabled.

3.7.4.3. The supply air temperature sensor acts as a high limit for each stage of heating (stage 1 heating disabled above 60 °C and enabled below 50 °C, stage 2 heating disabled above 55 °C and enabled below 45 °C) and a low limit for each stage of cooling (stage 1 disabled below 5 °C and enabled above 13 °C, stage 2 disabled below 8 °C and enabled above 18 °C).

3.7.4.4. The supply air temperature sensor acts as a software freezestat (triggered below 1 °C for 1 minute and restored above 5 °C after a 5 minute delay).

3.7.4.5. The supply fan has a delay-off time of 90 seconds.

3.7.4.6. The DX cooling has a minimum-off time of 5 minutes.

3.7.4.7. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 18 °C) or when fan is off.

3.7.4.8. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 14 °C) or when the fan is off.

3.7.4.9. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.7.4.10. Minimum outdoor air is provided when enabled by the global minimum outdoor air time schedule. The minimum outdoor air is adjustable from the graphic and is typically a default of 10 % open outdoor damper position.

3.7.4.11. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 % to 40 % as the reading increases from 1000 ppm to 1200 ppm (1000 ppm to 1200 ppm over a ramped 15 minute period).

3.7.4.12. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.7.4.13. During Occupied Mode, and the outdoor air temperature is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.7.4.14. The default room temperature cooling setpoint is 2 °C above the heating setpoint when mechanical cooling is enabled. The standard mechanical cooling room setpoint will be limited to a minimum of 23.5 °C.

3.7.4.15. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to standby mode of operation.

3.7.4.16. Minimum outdoor air is set to zero when the global ventilation schedule is off.

3.7.4.17. Supply and Return Fan(s) disabled if the hydronic heating coil pump status is not running when required.

3.7.4.18. Discretionary Fire Alarm Shutdown Mode to be enabled on the fire alarm status.

3.7.4.19. The heating coil pump (for hydronic units where applicable) turns off when the outside air temperature exceeds the heating disable setpoint (60 second delay-off time)

3.7.4.20. Cooling valves are closed when the outside air temperature is below the global cooling disable setpoint or the CW mains temperature is above 20°C

3.7.5. Alarms:

An alarm will be generated upon the following conditions:

3.7.5.1. Supply and and or Return Fan status does not match the start/stop signal.

3.7.5.2. Mixed air temperature too high alarm (triggered above 50 °C and restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7 °C). Low mixed air temperature alarm set to lower thresholds when Mixed Air Temperature sensor is installed after the DX or cooling coil.

3.7.5.3. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C)

3.7.5.4. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored below 36 °C) for cooling systems.

3.7.5.5. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.7.5.6. Weekly fan runtime limit exceeded.

3.7.5.7. Return air carbon dioxide too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 ppm and restored above 300 ppm) with a 15 minute delay.

3.7.5.8. Software freezestat tripped.

3.7.5.9. Low mixed air temperature alarm (triggered below 5 °C and restored above 7 °C).

3.7.5.10. Low return air carbon dioxide alarm (triggered below 250 ppm and restored above 275 ppm) or high return air CO2 alarm (triggered above 1200 ppm and restored below 1100 ppm).

3.7.5.11. High supply air static pressure alarm (triggered 30 % above setpoint and restored below 10 % above setpoint) or low supply air static pressure alarm (triggered 30 % below setpoint and restored above 10% below setpoint).
3.7.5.12. High supply air temperature alarm (triggered above 40 °C and restored below 38°C) or low supply air temperature alarm (triggered below 8 °C and restored above 10°C).
3.7.5.13. Low return air temperature alarm (triggered below 14 °C and restored above 15°C) or high return air temperature alarm (triggered above 40 °C and restored below 38 °C).
3.7.5.14. Freezestat or differential pressure limit switch tripped.
3.7.5.15. Hydronic heating coil pump status in wrong mode
3.7.5.16. Software freezestat tripped.

3.8. VAV AHU HVAC Fan System Sequence of Operations:

3.8.1. Discretionary Fire Alarm Shutdown Mode:
The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal AHU HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.8.2. Freezestat Shutdown Modes:
3.8.2.1. Software
The duct/unit mounted supply air temperature sensor acts as a software freezestat (triggered below 1 °C after 30 seconds, restored above 5 °C after 5 minutes.
3.8.2.2. Hard-Wired
BAS monitors the status of the duct mounted hard wired freeze-stat (provided by others, where applicable) that shuts down the AHU fan(s) and spring closes the outside air damper(s) if the air temperature leaving the heating coil falls below the freeze-stat setpoint.

3.8.3. Unoccupied Mode:
Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State and Pushbutton Override State to meet the demands from each state and return to the Idle State when the demands of each state are satisfied.
3.8.3.1. (Idle State)
The supply fan is off, the return fan is off (where applicable) power exhaust fan is off (where applicable), the Global Ventilation Schedule is disabled, the outdoor air mixing dampers are in the 0% outdoor air position, and cooling is disabled. The heating valve modulates to maintain a plenum temperature of 15°C when the outside air temperature is below 1 °C and closes when outside air temperature is above 3 °C. The heating coil circulating pump (where applicable) runs continuously when Heating Mode is enabled.
3.8.3.2. (Heating State)
System cycles on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C OAT or lower and 18.0 °C at -20.0 °C OAT or lower (each adjustable)
The VAV HVAC unit supply air static pressure setpoint is increased by 20 %. VFD(s) modulate to maintain static pressure setpoint.
Mechanical Cooling: Disabled
Free Cooling: Disabled
Global Ventilation Schedule: Disabled
3.8.3.3. (Push Button Override State)
If the override pushbutton is pressed, at any associated room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation enabled.
Mechanical Cooling: Enabled (per Cooling Enable Mode)
Free Cooling: Disabled
Global Ventilation Schedule: Enabled (only at the associated unit)

3.8.4. Morning Warmup Mode:
An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled.
The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled at full capacity and cooling is disabled.
The VAV VFD drive(s) starts in the minimum position.
The VAV boxes zone dampers start in the 100 % open position.

The Optimized Start Program is to begin up to 105 minutes before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to the occupancy setpoint.
Free Cooling: Disabled
Mechanical Cooling: Disabled
Global Ventilation Schedule: Disabled (outdoor dampers are closed)

3.8.5. Occupied Mode:

Time of day schedule, which starts the HVAC unit(s) along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule: Enabled
AHU HVAC unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room Heating Temperature Setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled Temperature Setpoint nominal 22.5 °C +/-1.0°C
Room mechanical cooling temperature setpoint nominal 24.5 °C +/- 1.0°C (adjustable)
Supply and return fans run continuously.
Supply air temperature sensor operates the heating valve (or stages of gas heating or modulating gas heating where applicable), the mixing dampers (for free cooling) and the chilled water valve (or stages of DX cooling where applicable) in sequence to maintain the Supply Air Temperature Setpoint
Supply air static pressure sensor controls the supply VFD fan speed to maintain the Supply Air Static Setpoint

3.8.6. Standby Occupancy Mode:

Time of day schedule controls the AHU HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday. (Between Occupied and Unoccupied Modes.)
Minimum outdoor air is set to zero when the global ventilation schedule is off).
Fan operation: Supply fan and return fan (where applicable) runs only on a call from heating or cooling only.
Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0°C (adjustable)
Free Cooling: Disabled
Mechanical Cooling: Enabled (Enabled when within the applicable limits and safeties)

3.8.7. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.
When the ventilation lockout switch is disengaged, systems return to mode of operation based on the time of day schedule.

3.8.8. Supply Air Temperature Setpoint:

The Supply Air Temperature Setpoint is reset between 13 °C to 16 °C as the outside air temperature falls from 22 °C to 10 °C.
The Supply Air Temperature Setpoint is also reset +/-5 °C based on the VAV box requiring the most cooling (based on the maximum of all the Cooling PIDs of the VAV boxes (with 10 minute ramping) associated with the VAV fan system).
The Supply Air Temperature Setpoint is limited to a range of 12 °C to 20 °C.

3.8.9. Supply Air Static Pressure Setpoint:

The Supply Air Static Setpoint which is reset between 200 Pa and 300 Pa as the outside air temperature rises from –10 °C to 25°C.

3.8.10. Heating Sequence:

3.8.10.1. Default Setpoint:

When the Heating Mode is active, the Supply Air Temperature Setpoint remains unchanged.

3.8.10.2. Call for Heating:

Mechanical heating is used until the heating calls (from room controller PID, typically stage 1 heating is enabled at 25 %Clg PID signal and disabled at 50 %Clg PID signal and stage 2 heating is enabled at 5 %Clg PID signal and disabled at 25 %Clg PID signal or Night Setback thresholds) are satisfied.

Natural Gas

For Modulating Burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the rooftop unit to 17 °C). A 100% signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the rooftop unit to 35 °C).
The room temperature sensor regulates heating output to maintain the occupied heating setpoint. Local setpoint adjustment is provided. The power exhaust fan or return fan (if applicable) cycles based on the rooftop economizer position.

Hydronic

For units with Heating Valves, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (below 2 Volts) opens the heating valve. (Note:The heating valve is reverse acting to the controller output signal and is to fail safe open)
The heating coil circulating pump (where applicable) runs continuously in winter.

Radiation Zone

Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be substituted as the first stage of heating.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.8.11. Mechanical Cooling Sequence:

3.8.11.1. Default Setpoint:

When the Cooling Mode is active, the Supply Air Temperature Setpoint remains unchanged.

3.8.11.2. Call for Cooling:

When Free Cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the supply air temperature cooling calls (from supply air controller PID, typically stage 1 cooling is enabled at 65 %Clg PID signal and disabled at 60 %Clg PID signal and stage 2 cooling is enabled at 95 %Clg PID signal and disabled at 60 %Clg PID signal) are satisfied.
The supply air temperature sensor also modulates the mixing dampers (for free cooling) to maintain the occupied free cooling setpoint.

Chilled Water Cooling

For units with Cooling Valves, (where applicable) 0 % signal (0 Volts) closes the cooling valve. A 100% signal (10 Volts) opens the cooling valve. (Note:The cooling valve is direct-acting to the controller output signal and is to fail safe closed) .

3.8.12. Economizer Operation (Free Cooling) and Carbon Dioxide Demand Control Ventilation:

3.8.13. Default Room Temperature Setpoint

When the Free Cooling Mode is active, the Supply Air Temperature Setpoint remains unchanged.

3.8.13.1. Minimum Outdoor Air Damper Position

A typical value for minimum outdoor air damper position is 10 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate. Minimum outdoor air damper position signal may exceed the economizer signal.

3.8.13.2. Economizer Operation

The outdoor air mixing dampers will be set to the minimum outdoor air position unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).
If Free Cooling is enabled during Occupied Mode, economizer operation will be substituted for first stage mechanical cooling, the mixing dampers will be modulated open on a call for cooling to provide ‘free’ cooling.
For air handling units with power exhaust (where applicable), the exhaust fan runs when the outdoor air damper is more than 50 % open

3.8.13.3. During morning warm-up, the outdoor air minimum position is set to zero.

3.8.13.4. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.8.13.5. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1000 ppm to 1200 ppm over a ramped 15 minute period). CO_2 levels are automatically logged at 10 minute intervals

3.8.13.6. Additional Rooms Partition Switch

Any additional room(s) (ie. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read “No Cooling when Partition is Open to Gym”.

3.8.14. Limits and Safeties

3.8.14.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature during startup. At -20 °C outdoor air temperature, and below, the maximum outdoor air damper position will be 0% open and at 10 °C outdoor air temperature the maximum outdoor air damper position will be 100 %.

3.8.14.2. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively high supply air temperature. At 30 °C outdoor air temperature and above, the maximum outdoor air damper position will be 0% open and at 10°C outdoor air temperature, the maximum outdoor air damper position will be 100%

3.8.14.3. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11 °C). In applications where the mixed air sensor is located after the DX cooling coil, the setpoint is reduced (to typically 5 °C) when DX cooling is enabled

3.8.14.4. The duct mounted supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60 °C, and enable below 50 °C, for stage 2:disable above 55 °C and enable below 45 °C) and a low limit for each stage of cooling (for stage 1: disable DX1 below 5 °C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13 °C enable DX2).

3.8.14.5. The duct/unit mounted supply air temperature sensor acts as a software freezestat (triggered below 1°C after 30 seconds, restored above 5 °C after 5 minutes.

3.8.14.6. The supply fan has a delay-off time of 90 seconds.

3.8.14.7. The DX cooling has a minimum-off time of 5 minutes.

3.8.14.8. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 2 °C below Cooling Enable setpoint) or when fan is off.

3.8.14.9. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.8.14.10. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.8.14.11. The default zone setpoint is increased by 3°C when mechanical cooling is enabled (providing heating is disabled). The standard mechanical cooling setpoint will be limited to a (minimum of 23.5 °C - adjustable).

3.8.14.12. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode.

3.8.14.13. Minimum outdoor air is provided when enabled by the Global Ventilation Schedule.

3.8.14.14. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 to 40 % as the reading increases from 1000 ppm to 1200 ppm.

3.8.14.15. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.8.14.16. During Occupied Mode, and the outdoor air is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.8.14.17. Minimum outdoor air is set to zero when the global ventilation schedule is off.

3.8.14.18. Mixed air low pressure switch shuts down the fans if the pressure falls below setpoint.

3.8.14.19. Supply air high pressure switch shuts down the fans if the pressure exceeds the setpoint.

3.8.14.20. A supply air static pressure high limit control is provided (initially set at 400 Pa).

3.8.14.21. Mixed air sensor acts as a low limit to prevent the mixed air temperature from falling below setpoint (initially 12 °C).

3.8.14.22. The heating coil pump turns off when the outside air temperature exceeds the heating disable setpoint (60 s delay-off time).

3.8.14.23. The fan drives will not exceed 60 % until the supply air static pressure exceeds 25 Pa (to ensure a smooth start-up).

3.8.14.24. As the %OA increases from 0 % to 15 % the return fan speed drops from 100 % to 90 % of the supply fan speed.

3.8.14.25. The outdoor air damper shuts if the hydronic heating coil pump status is not running when required.

3.8.15. Alarms:

An alarm will be generated upon the following conditions:

3.8.15.1. Fan status does not match the start/stop signal.

3.8.15.2. Mixed air temperature too high alarm (triggered above 50 °C and restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7 °C). Low mixed air temperature alarm set to lower thresholds when Mixed Air Temperature sensor is installed after the DX or cooling coil.

3.8.15.3. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C)

3.8.15.4. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored above 36 °C) for cooling systems.

3.8.15.5. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.8.15.6. Weekly fan runtime limit exceeded.

3.8.15.7. Return air carbon dioxide too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 ppm and restored above 300 ppm) with a 15 minute delay.

3.8.15.8. Software freezestat tripped.

3.8.15.9. High supply air static pressure alarm (triggered 30% above setpoint and restored 10% above setpoint) or low supply air static pressure alarm (triggered 30% below setpoint and restored 10% above setpoint).

3.8.15.10. Low return air temperature alarm (triggered below 14 °C and restored above 15 °C) or high return air temperature alarm (triggered above 40 °C and restored below 38 °C).

3.8.15.11. Freezestat or differential pressure limit switch tripped.

3.8.15.12. Hydronic heating pump status does not match the start/stop signal.

3.8.16. VAV Box Sequence of Operations:

Each VAV box mode of operation tracks with its associated VAV Fan System mode of operation. The duct supply air temperature is sent to each associated VAV box and is used by the VAV box along with the space temperature to determine air flow setting in each mode of operation. Each VAV box (unless otherwise noted) has a space temperature sensor with setpoint adjust and push button override. Each VAV box reports its cooling demand back to its associated VAV fan system to reset the supply air temperature setpoint.

3.8.16.1. Fan Powered VAV Box (with reheat coil / radiant panel)

The space temperature sensor modulates the VAV box (between minimum and maximum air flow settings) in sequence with the reheat coil and/or radiant panel (if applicable) to maintain setpoint. A velocity sensor controls the air flow between minimum and maximum settings. The minimum air flow setting is adjusted based on the need for reheat.

The fan runs continuously during occupied periods and the reheat valve modulates. Fans start 5 minutes before the air handling unit starts. When the central system is off, the primary air damper is closed. When Unoccupied, the fan cycles as required (with the reheat valve open) to maintain the unoccupied setpoint.

Science / Art Rooms - When the local fume hood is energized, the minimum air flow setting is increased to 50 %. When the local room exhaust fan is energized, the VAV box opens to 100 % flow.

3.8.16.2. Damper-Only (no reheat or fan-powered box)

The space temperature sensor modulates the VAV box (between the minimum and maximum air flow.settings) to maintain airflow setpoint. A velocity sensor controls the air flow between minimum and maximum air flow settings.

Science / Art Rooms - When the local fume hood is energized, the minimum air flow setting is increased to 50 %. When the local room exhaust fan is energized, the VAV box opens to 100 % flow.

3.8.16.3. Damper-Only (with reheat coil / radiation valve)

The space temperature sensor modulates the VAV box (between minimum and maximum air flow settings) in sequence with the reheat coil and/or radiant panel (if applicable) to maintain setpoint. A velocity sensor controls the air flow between minimum and maximum settings. The minimum air flow setting is adjusted based on the need for reheat.

Science / Art Rooms - When the local fume hood is energized, the minimum air flow setting is increased to 50 %. When the local room exhaust fan is energized, the VAV box opens to 100 % flow.

3.8.16.4. Fan Powered VAV Bypass / Dump Box (with reheat coil / radiant panel)

The space temperature sensor modulates the VAV box (air flow intake settings) in sequence with the reheat coil and/or radiant panel (if applicable) to maintain setpoint. A velocity sensor controls the intake air flow between minimum and maximum settings. The minimum air flow setting is adjusted based on the need for reheat. Return air is introduced into the return side of the box to balance the intake air floor so that the discharge air is constant.

The fan runs continuously during occupied periods and the reheat valve modulates. Fans start 5 minutes before the air handling unit starts. When the central system is off, the primary air damper is closed. When Unoccupied, the fan cycles as required (with the reheat valve open) to maintain the unoccupied setpoint.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

Science / Art Rooms

When the local fume hood is energized, the minimum air flow setting is increased to 50 %. When the local room exhaust fan is energized, the VAV box opens to 100 % flow.

3.9. Multizone HVAC Sequence of Operations:

3.9.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, the return fan is off (where applicable) and power exhaust fan is off (where applicable), the outdoor air mixing dampers are in the 0% outdoor air position, heating is disabled and cooling is disabled. The zone dampers are in the 50 % cooling position. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.9.2. Freeze-stat Shutdown Mode(s):

3.9.2.1. Software

The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 3 minute delay, restored above 5 °C after 3 minute delay and auto reset after 5 minute delay)

3.9.2.2. Hard-Wired

In addition BAS monitors status of the hard wired freeze-stat (provided by others, where applicable) that shuts down the AHU fan(s) and spring closes the outside air damper(s) if the air temperature leaving the heating coil falls below the freeze-stat setpoint.

3.9.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.

The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.

The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.9.3.1. (Idle State)

The supply fan is off, the return fan is off (where applicable) power exhaust fan is off (where applicable), the Global Ventilation Schedule is disabled, the outdoor air mixing dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. The zone dampers are in the 50 % cooling position.

3.9.3.2. (Heating State)

System cycles on a call for unoccupied heating
Supply fan cycles on, associated exhaust or return fan cycles on (where applicable).
A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
For modulating burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum discharge temperature (typically set on the multizone unit to 17 °C). A 100 % signal (10 Volts) heating discharge temperature setpoint is at maximum discharge temperature setpoint (typically set on the multizone unit to 35 °C).
Associated zone damper(s) modulate to obtain setpoint.
Unoccupied Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C Outdoor Air Temperature or lower and 18.0 °C at -20.0 °C Outdoor Air Temperature or lower (each adjustable)
Mechanical Cooling: Disabled
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.9.3.3. (Push Button Override State)

The default room temperature setpoint remains unchanged.
Idle state of the unoccupied mode is exited if the override pushbutton is pressed, (for a minimum of 2 seconds) at any room sensor.
The associated system will switch to the Occupied Mode for 2 hours (adjustable).
Free Cooling: Disabled
Mechanical Cooling: Enabled
Global Ventilation: Enabled
The system returns to idle state in the unoccupied mode after the 2 hours after the pushbutton trigger has elapsed.

3.9.4. Morning Warmup Mode:

An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The supply fan is on, the return fan is on (where applicable), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled at full capacity and the cooling is disabled.
The zone dampers modulate to maintain space temperature.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.
Free Cooling: Disabled
Mechanical Cooling: Disabled
Global Ventilation Schedule: Disabled
The system exits Morning Warm Up Mode and continues into occupied mode when the lowest indoor zone temperature is warmed up to default room temperature setpoint.

3.9.5. Occupied Mode:

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
Unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and return fan (where applicable) run continuously.
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled temperature setpoint nominal 22.5 °C +/-1.0 °C
Room mechanical cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Global Ventilation Schedule: Enabled

3.9.6. Standby Occupancy Mode:

Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.
Minimum outdoor air is set to zero when the global ventilation schedule is off.
Fan operation: Supply fan and return fan (where applicable) runs only on a call from heating or cooling.
Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.9.7. Zone Damper Control

3.9.8. The room temperature sensor modulates the zone damper to maintain the occupied room temperature setpoint. Local setpoint adjustment is provided

3.9.9. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.9.10. Heating Sequence:

3.9.10.1. Outdoor Air Temperature used to determine Heating Enable Mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the Outdoor Air Temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.9.10.2. Default Setpoint:

When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.9.10.3. Call for Heating:

3.9.10.4. Hot Deck

Mechanical heating is used until the heating calls (from hot deck controller PID or Night Setback thresholds) are satisfied.
For Modulating Burners, (where applicable) 0 % signal (0 Volts) heating discharge temperature setpoint is at minimum hot deck temperature (typically set on the rooftop unit to 17 °C). A 100% signal (10 Volts) heating discharge temperature setpoint is at maximum hot deck temperature setpoint (typically set on the rooftop unit to 35 °C).
The hot deck temperature sensor regulates heating output to maintain the hot deck heating setpoint.
The power exhaust fan or return fan (if applicable) cycles based on the rooftop economizer position.
The hot deck sensor resets the setpoint of the burner controller (modulating burner controlled by the rooftop unit heating controller according to hot deck temperature) based on the coldest zone deviation from setpoint as follows:

Deviation	Hot Deck Setpoint
0.0 °C	Minimum (17 °C)
-2.0 °C	Maximum (35 °C)

Hydronic

For Heating Valve, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100 % signal (below 2 Volts) opens the heating valve.

Radiation Zone

Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be substituted as the first stage of heating.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.9.11. Cooling Sequence:

3.9.11.1. Outdoor air temperature used to determine cooling enable mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.9.11.2. Default Setpoint:

When the cooling enable mode is active, the default room temperature setpoint is raised by 3 °C.

3.9.11.3. Call for Cooling:

3.9.11.4. Cold Deck

When free cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the cooling calls (from cold deck controller PID) are satisfied.
The cold deck temperature sensor also modulates the mixing dampers (for free cooling) to maintain the cold deck setpoint.
The cold deck temperature sensor modulates the mixing dampers to maintain the cold deck setpoint which is reset based on the warmest zone deviation from setpoint as follows:

Deviation	Cold Deck Setpoint
0.5 °C	20 °C
2 °C	13 °C

Zone Damper Control:
(same as heating sequence) The room temperature sensor modulates the zone damper to maintain the occupied room temperature setpoint.

3.9.12. Ventilation Sequence:
Not applicable as hot deck and cold deck temperatures are maintained to setpoint simultaneously.

3.9.13. Economizer Operation (and CO_2 Demand Control Ventilation) :

3.9.13.1. During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the mixing dampers will be modulated open on a call for cooling to provide 'free' cooling.

3.9.13.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 5 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.

3.9.13.3. For units with power exhaust, the exhaust fan runs when the outdoor air damper is more than 50 % open.

3.9.13.4. During morning warm-up, the outdoor air minimum position is set to zero.

3.9.13.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.9.13.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint Sequence of Operation, the mixing dampers will be set to the minimum outdoor air threshold unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).

3.9.13.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1000 ppm to 1200 ppm over a ramped 15 minute period).

3.9.13.8. CO_2 levels are automatically logged at 10 minute intervals (adjustable).

3.9.14. Additional Rooms Partition Switch
Any additional room(s) (i.e. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read "No Cooling when Partition is Open to Gym".

3.9.15. Limits and Safeties

3.9.15.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature. At -15 °C or below, outdoor air temperature, the maximum outdoor air damper position will be 0 % open and at 10 °C outdoor air temperature, the maximum outdoor air damper position will be 100 %.

3.9.15.2. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively high supply air temperature. At 30 °C outdoor air temperature and above, the maximum outdoor air damper position will be 0 % open and at 10 °C outdoor air temperature, the maximum outdoor air damper position will be 100 %

3.9.15.3. The mixed air temperature sensor acts as a low limit to ensure temperature does not fall below setpoint (typically 11 °C). In applications where the mixed air sensor is located after the DX cooling coil, the setpoint is reduced (to typically 5 °C) when DX cooling is enabled.

3.9.15.4. The hot deck air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60 °C , and enable below 50 °C, for stage 2: disable above 55 °C and enable below 45 °C) and the cold deck air temperature sensor a low limit for each stage of cooling (for stage 1: disable DX1 below 5°C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13 °C enable DX2).

3.9.15.5. The hot deck air temperature sensor acts as a software freezestat (triggered below 1 °C for 3 minutes, restored above 5 °C for 3 minute) auto reset after 5 minute delay.

3.9.15.6. The supply fan has a delay-off time of 90 seconds.

3.9.15.7. The DX cooling has a minimum-off time of 5 minutes.

3.9.15.8. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 2 °C below Cooling Enable setpoint) or when fan is off.

3.9.15.9. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.9.15.10. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.9.15.11. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.9.15.12. During Occupied Mode, and the outdoor air is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.9.15.13. The default zone setpoint is increased by 3°C when mechanical cooling is enabled (providing heating is disabled). The standard mechanical cooling setpoint will be limited to a (minimum of 23.5 °C - adjustable).

3.9.15.14. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode.

3.9.15.15. Minimum outdoor air is provided when enabled by the Global Ventilation Schedule.

3.9.15.16. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 to 40 % as the reading increases from 1000 ppm to 1200 ppm.
3.9.15.17. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.
3.9.15.18. During Occupied Mode, and the outdoor air is above -1°C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3°C with a +2°C deadband.
3.9.15.19. Minimum outdoor air is set to zero when the Global Ventilation Schedule is off.

3.9.16. Alarms:
An alarm will be generated upon the following conditions:
3.9.16.1. Fan status does not match the start/stop signal.
3.9.16.2. Mixed air temperature too high alarm (triggered above 50 °C and restored below 48 °C) or too low alarm (triggered below 5 °C and restored above 7 °C). Low mixed air temperature alarm set to lower thresholds when Mixed Air Temperature sensor is installed after the DX/cooling coil.
3.9.16.3. Hot deck air temperature too high alarm (triggered above 45 °C and restored below 43 °C) or sensor fault.
3.9.16.4. Cold deck air temperature too low alarm (triggered below 5 °C and restored above 7 °C) or sensor fault.
3.9.16.5. Zone temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored below 36 °C) for cooling systems.
3.9.16.6. Zone temperature too low alarm (triggered below 14 °C and restored above 16°C).
3.9.16.7. Weekly fan runtime limit exceeded.
3.9.16.8. Return air CO_2 too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 ppm and restored above 300 ppm) with a 15 minute delay.
3.9.16.9. Software freezestat tripped.

3.10. Heat Pump Gas Fired Multi Zone Sequence of Operations

3.10.1. System Integration Guidelines:
3.10.1.1. Output Points
All CME multizone equipment points (fan speed, outdoor damper, heating, cooling, exhaust fans) are connected directly to the CME Multi Zone manufacturer's PMZ controller commanded indirectly through parameters via BACnet MS/TP.
3.10.1.2. Input Points:
Zone temperature, setpoint adjust, pushbutton overrides are provided by the Control Contractor, interfaced into the BAS system and the data is sent to the PMZ controller via BACnet MS/TP.
Supply air temperature, Return air temperature, Return Air Carbon Dioxide sensors, Fan Low Speed Status, Fan High Speed Status are connected directly to the Multi Zone manufacturer's PMZ controller. The data from the PMZ is read by the BAS via BACnet MS/TP).
3.10.1.3. Setpoints and Schedules
Setpoints and Schedules are determined as detailed in the following Sequence of Operations and are sent to the PMZ controller via BACnet MS/TP

3.10.2. Discretionary Fire Alarm Shutdown Mode:
The supply fans are off and power exhaust fans are off (where applicable), the outdoor air dampers are in the 0% outdoor air position, heating is disabled and cooling is disabled. The two-position zone dampers (where applicable) are in the closed position. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.10.3. Freeze-stat Shutdown Mode(s):
3.10.3.1. Software
The duct/unit mounted supply air temperature sensor (connected to the Multizone manufacturer's PMZ controller and monitored via BACnet MS/TP) acts as a software freeze-stat (triggered below 1 °C after 1 minute delay, restored above 5 °C after 5 minute delay).
3.10.3.2. Hard-Wired
In addition BAS monitors status of the hard wired freeze-stat (provided by others, where applicable) that shuts down the AHU fan(s) and spring closes the outside air damper(s) if the air temperature leaving the heating coil falls below the freeze-stat setpoint.

3.10.4. Unoccupied Mode:
Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes.
The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.10.4.1. (Idle State)

The supply fan is off, the power exhaust fans are off (where applicable), the Global Ventilation Schedule is disabled, the outdoor air dampers are in the 0 % outdoor air position, heating is disabled and cooling is disabled. The two-position zone dampers are in the closed position.

3.10.4.2. (Heating State)

System cycles on a call for unoccupied heating (which is triggered by the System Minimum Zone Temperature falling below the Unoccupied Heating Room Setpoint).
Supply fan cycles on..
A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Unoccupied Heating Room Temperature Setpoint nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C Outdoor Air Temperature or lower and 18.0 °C at -20.0 °C Outdoor Air Temperature or lower (each adjustable).
The outdoor air temperature is also used to determine the heat-pump heating enable point. Below the heat-pump enable outdoor air temperature setpoint the heating is provided by gas fired heating.
Mechanical Cooling: Disabled
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.10.4.3. (Push Button Override State)

The default room temperature setpoint remains unchanged.
Idle state of the unoccupied mode is exited if the override pushbutton is pressed, (for a minimum of 2 seconds) at any room sensor.
The associated system will switch to the Occupied Mode for 2 hours (adjustable).

Free Cooling: Disabled
Mechanical Cooling: Enabled
Global Ventilation: Enabled
The system returns to idle state in the unoccupied mode after the 2 hours after the pushbutton trigger has elapsed.

3.10.5. Morning Warmup Mode:

An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The furnace supply fans are on (at high speed when heating is required), the outdoor air mixing dampers are in the 0 % outdoor air position, heating is enabled and the cooling is disabled.
The zone dampers open (where applicable) to maintain space temperature.
The optimized start program is to begin up to 105 minutes (adjustable) before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.
Free Cooling: Disabled
Mechanical Cooling: Disabled
Global Ventilation Schedule: Disabled
The system exits Morning Warmup Mode and continues into occupied mode when the lowest indoor zone temperature is warmed up to default room temperature setpoint.

3.10.6. Occupied Mode:

Time of day schedule, which starts the unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
Unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan runs continuously and the exhaust fans stage on as required.
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled temperature setpoint nominal 22.5 °C +/-1.0 °C
Room mechanical cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Global Ventilation Schedule: Enabled

3.10.7. Standby Occupancy Mode:

Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.
Minimum outdoor air is set to zero (with future provision to adjust) when the global ventilation schedule is off. .
Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.10.8. Zone Damper Control

The zone temperatures are monitored and sent to the manufacturer supplied PMZ controller.
Zone space temperature sensors open their respective two-position zone damper (where applicable) to maintain setpoint. An adjustment of +/-1°C is provided at each room temperature sensor. The default space temperature setpoint is raised 3 °C when DX cooling is enabled.
The zone dampers are set to minimum ventilation air flow by the balancer when 'closed'. To maintain minimum ventilation air during Occupied Mode

3.10.9. Ventilation Lockout (Sequence):

When the ventilation lockout switch, usually located in the Custodial Office, is engaged, all outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode of operation.

3.10.10. Heating Sequence:

3.10.10.1. Outdoor Air Temperature used to determine Heating Enable Mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the Outdoor Air Temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.
The outdoor air temperature is also used to determine the heat-pump heating enable point. Below the heat-pump enable outdoor air temperature setpoint the heating is provided by gas fired heating.

3.10.10.2. Default Setpoint:

When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.10.10.3. Call for Heating:

3.10.10.4. Dedicated Furnace

The furnace fan goes into high speed during heating mode.
Mechanical heating is used until the heating calls (from Furnace controller PID or Night Setback thresholds) are satisfied.
Condensers act as heat pumps and provide heating until outside air temperature falls below 5 °C (Adjustable based on defrost operation).
Below this heat-pump outdoor air temperature setpoint the gas heating is used to provide heating.

Radiation Zone

Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be substituted as the first stage of heating.

Supplemental Electric Space Heating

Where there is a zone supplemented by electric space heating, the electric heater starts (where applicable) and is to be utilized as the second stage of heating.

3.10.11. Cooling Sequence:

3.10.11.1. Outdoor air temperature used to determine cooling enable mode:

A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.10.11.2. Default Setpoint:

When the cooling enable mode is active, the default room temperature setpoint is raised by 3 °C.

3.10.11.3. Call for Cooling:

3.10.11.4. Dedicated Furnace

The furnace fan goes into high speed during cooling mode.
When free cooling is available, and a demand for cooling is in place, free cooling will be used first, and if the demand for cooling is still in place, mechanical cooling will be used until the cooling calls controller PID are satisfied.

Zone Damper Control:

The zone temperatures are monitored and sent to the manufacturer supplied PMZ controller.
Zone space temperature sensors open their respective two-position zone damper to maintain setpoint. An adjustment of +/-1.5°C is provided at each room temperature sensor. The default space temperature setpoint is raised 3 °C when DX cooling is enabled.

3.10.12. Ventilation Sequence:

The outdoor air flow rate is calculated according to each fan speed and outdoor air damper position and this cycles on the exhaust fans to balance the air flow.

3.10.13. Economizer Operation (and CO_2 Demand Control Ventilation) :

3.10.13.1. During Occupied Mode, economizer operation will be substituted for first stage mechanical cooling when the outdoor air temperature and relative humidity are below the Free Cooling Setpoint Sequence of Operation. If the outdoor air temperature is below this free cooling setpoint the outdoor air dampers will be modulated open on a call for cooling to provide 'free' cooling.

3.10.13.2. Minimum outdoor air damper position signal may exceed the economizer signal. A typical value for minimum outdoor air damper position is 10 % outdoor air, (0 % when an associated stand alone ERV is present) which can vary based on use case of the occupied space based on ASHRAE 62.1 net occupiable floor area outdoor air rate.

3.10.13.3. For units with power exhaust, the exhaust fans stage on when the outdoor air damper is more than 50 % open.

3.10.13.4. During morning warm-up, the outdoor air minimum position is set to zero.

3.10.13.5. During Unoccupied Mode and Standby Occupancy Mode, free cooling is unavailable.

3.10.13.6. During Occupied Mode, If the outdoor air temperature and relative humidity are above the Free Cooling Setpoint, the mixing dampers will be set to the minimum outdoor air position unless otherwise required under ASHRAE 62.1 Ventilation Rate Procedure - net occupiable floor area outdoor air rate (w/ CO_2 demand controlled ventilation reset).

3.10.13.7. Each return air duct-mounted or space mounted CO_2 sensor acts as a high limit and will increase the amount of minimum outdoor air, to a maximum of 40 % outdoor air as the CO_2 level increases from 1000 ppm to 1200 ppm over a ramped 15 minute period).

3.10.14. Additional Rooms Partition Switch

3.10.14.1. Any additional room(s) (i.e. Music Rooms) that are separated by a partition wall, will disable mechanical cooling (where applicable) for the associated units that serve the additional room(s). If the Music Room wall is open to the Gym, mechanical cooling serving the Music Room is disabled. Partition switch and lamacoid label to be provided above Music Room Sensor by the Building Automation Contractor. Label to read “No Cooling when Partition is Open to Gym”

3.10.15. Limits and Safeties

3.10.15.1. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively low supply air temperature. At -15 °C or below, outdoor air temperature, the maximum outdoor air damper position will be 0% open and at 10 °C outdoor air temperature, the maximum outdoor air damper position will be 100 %.

3.10.15.2. The maximum outdoor air damper position is limited based on the outdoor air temperature to prevent excessively high supply air temperature. At 30 °C outdoor air temperature and above, the maximum outdoor air damper position will be 0% open and at 10 °C outdoor air temperature, the maximum outdoor air damper position will be 100 %

3.10.15.3. The supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60 °C, and enable below 50 °C, for stage 2: disable above 55 °C and enable below 45 °C) and the cold deck air temperature sensor a low limit for each stage of cooling (for stage 1: disable DX1 below 5°C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13 °C enable DX2).

3.10.15.4. The supply air temperature sensor acts as a software freezestat (triggered below 1 °C for 1 minute, restored above 5 °C for 1 minute) auto reset after 5 minute delay.

3.10.15.5. The supply fan has a delay-off time of 90 seconds.

3.10.15.6. The DX cooling has a minimum-off time of 5 minutes.

3.10.15.7. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 2 °C below Cooling Enable setpoint) or when fan is off.

3.10.15.8. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.10.15.9. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.10.15.10. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.10.15.11. During Occupied Mode, and the outdoor air is above -1 °C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3 °C with a +2 °C deadband.

3.10.15.12. The default zone setpoint is increased by 3 °C when mechanical cooling is enabled (providing heating is disabled). The standard mechanical cooling setpoint will be limited to a (minimum of 23.5 °C - adjustable).

3.10.15.13. When the ventilation lockout switch (usually located at the custodial office) is engaged, the outdoor air dampers close, free cooling is disabled, and the system switches to Standby Occupancy Mode.

3.10.15.14. Minimum outdoor air is provided when enabled by the Global Ventilation Schedule.

3.10.15.15. The return air carbon dioxide sensor acts as a high limit to increase the amount of minimum outdoor air from 0 to 40 % as the reading increases from 1000 ppm to 1200 ppm.

3.10.15.16. During Occupied Mode, and the outdoor air is above -1°C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3°C with a +2°C deadband.

3.10.15.17. Minimum outdoor air is set to zero when the Global Ventilation Schedule is off.

3.10.16. Alarms:

3.10.16.1. An alarm will be generated upon the following conditions:

3.10.16.2. Fan status does not match the start/stop signal.

3.10.16.3. Supply air temperature too high alarm (triggered above 45 °C and restored below 43 °C) or sensor fault.

3.10.16.4. Supply air temperature too low alarm (triggered below 5 °C and restored above 7 °C) or sensor fault.

3.10.16.5. Zone temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38 °C and restored below 36 °C) for cooling systems.

3.10.16.6. Zone temperature too low alarm (triggered below 14 °C and restored above 16°C).

3.10.16.7. Weekly fan runtime limit exceeded.

3.10.16.8. Return air CO_2 too high alarm (triggered above 1700 ppm and restored below 1650 ppm) or too low alarm (triggered below 250 ppm and restored above 300 ppm) with a 15 minute delay.

3.10.16.9. Software freezestat tripped.

3.11. Hydronic Heating System with Non-Condensing Boiler Sequence of Operations:

3.11.1. System Enable/Disable Criteria for Winter Mode:

Winter Mode is active between September 16 and May 15 (adjustable).
When Winter Mode is active the heating system is enabled no matter what the outdoor air temperature is so that a failure of the outdoor air temperature sensor or the networking of it to other controllers does not cause a no-heat condition.
Once the heating system is enabled, the sequence is followed starting with 3.10.4 Hot Water Supply Setpoint Determination.

3.11.2. System Enable/Disable Criteria for Summer Mode:

Summer Mode is active between May 16 and September 15 (adjustable)
The heating system is enabled when the outdoor air temperature is lower than 16 °C and disabled when the outdoor air temperature goes above 16 °C with a 2 °C deadband.
Once the heating system is enabled, the sequence is followed starting with 3.10.4 Hot Water Supply Setpoint Determination.
When the heating system is disabled in summer mode, the boilers, main and circulation pumps are shut off.
The primary heating pumps have a delay-off time of 5 minutes.

3.11.3. Inter-boiler Runtime Delay:

In winter mode the lead boiler must run at least 5 minutes before the next boiler can start.
In summer mode the delay is increased to 30 minutes.

3.11.4. Hot Water Supply Temperature Setpoint Determination (outdoor reset schedule)

The Hot Water Supply Temperature Setpoint is the sum of the Outdoor Air Temperature Reset calculation and the sum of the applicable offsets based on the current Mode of Operation.
General Equation:
Hot Water Supply Temperature Setpoint = Outdoor Air Temperature Reset Calculation + Return Water Temperature Offset + Morning Warm-Up Offset + Unoccupied Setback Offset + Minimum Zone Temperature Deviation Reset Offset
Resets and Offset Calculations:
Outdoor Air Temperature Reset Calculation: The Hot Water Supply Temperature Setpoint is reset from the outdoor air temperature as per the following linear reset schedule:

For non-condensing boilers:

Outdoor Air Temperature (adjustable)	Heating Water Supply Temperature (adjustable)
16 °C	60 °C
-20 °C	90 °C

Return Water Temperature Offset:
The hot water supply temperature setpoint is further offset +5 °C to maintain boiler entering water above 55 °C to minimize condensation:

Heating Water Return Temperature	Heating Supply Water Temperature Offset
52 °C	5 °C
55 °C	0 °C

Morning Warm-Up Temperature Offset:
The hot water supply temperature setpoint has a +10 °C offset (adjustable) added during morning warm-up mode.

Unoccupied Mode (active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday)
The hot water supply temperature setpoint is reduced by -5 °C (adjustable) for unoccupied and setback.

Minimum Zone Temperature Deviation Reset Offset:
The hot water supply temperature setpoint is also reset +/- 5 °C (linear reset) based on the minimum zone temperature deviation (adjacent group of hydronic heater / wing in the school) from setpoint when in Occupied Mode usually between 7:00 a.m. and 11:00 p.m. Monday to Friday.

3.11.5. Unoccupied Mode:

The heating system is in unoccupied mode when the Time Schedule is not in Occupied or Morning-Warm-Up Mode,

3.11.6. Morning Warm-Up Mode:

During the optimum start, the heating system will be in Morning Warm-Up Mode.

The optimized start program, based on outdoor air temperature and time of day schedule, is to begin up to 120 minutes (adjustable) before the occupancy schedule to allow for morning warm up.
The optimized start time is calculated based on how long the hot water supply temperature has historically taken to reach setpoint at the current outdoor air temperature.

3.11.7. Occupied Mode

The heating system is Occupied Mode as determined by the associated Time Schedule usually between 7:00 a.m. and 11:00 p.m. Monday to Friday.
Boilers are modulated by the BAS to maintain supply water temperature setpoint.
Boilers are cycled on a call from supply water temperature in sequence to maintain the Hot Water Supply Temperature Setpoint.
The control loop PID modulates or stages the boilers to maintain the Hot Water Supply Temperature at Setpoint. The PID output is divided into the number of boilers.
For 2 primary boilers, each boiler would operate with 50 % of the full 100 % of the PID % Htg output. There is a 300 second delay between stages. First the lead boiler, then the lag boiler, as the PID % Htg output increases. The lead and lag boilers are reassigned weekly to equalize run-time.
For 3 primary boilers: each boiler would operate through 33 % of the full 100 % of the PID Htg output. There is a 300 second delay between stages. First the lead boiler, then the lag1 boiler, then lag2 as the PID % Htg output increases. The lead and lag boilers are reassigned weekly to equalize run-time.
For 4 primary boilers: each boiler would operate through 25 % of the full 100 % of the PID % Htg output. There is a 300 second delay between stages. First the lead boiler, then the lag1 boiler, then lag2, then lag3 as the PID % Htg output increases. The lead and lag boilers are reassigned weekly to equalize run-time.
For systems with special purpose boilers such as:
a) one modulating boiler working with other on/off boilers: the modulating boiler would run to maintain setpoint when there is less than one boiler's output required to meet the heating load in order to reduce cycling of the boilers.
b) one condensing boiler working with other non-condensing boilers: the condensing boiler runs to increase low return water temperatures above the condensing temperature for the other boilers. If the condensing boiler fails or is taken out of service, the return water setpoint is adjusted up to avoid condensation in the other boilers.

3.11.8. Lead/Lag operation:

Provided for boilers on a weekly basis. Typically rotated on a Tuesday at 1:00 p.m. when a new lead boiler is assigned. The next lag boiler is to start should the Lead Boiler fail to start.
The boiler circulating pumps are hard wired by the Mechanical Contractor to the local boiler controls and flow switch(s) so that each boiler starts when the associated pump is confirmed running through the flow switch(s). The boiler circulating pump current draws are monitored by BAS to determine status.

3.11.9. Main Heating Pumps:

One of the main heating pumps will operate continuously when heat is enabled. They operate on a weekly lead/lag operation, typically rotated on a Thursday at 1:00 p.m. when a new lead pump is assigned. (Lag pump starts if lead pump fails or is in alarm mode)
Main heating pumps are monitored by BAS for status.
Main heating pumps are exercised to run for 10 minutes once a week, typically lead pump on a Thursday at 1:00 p.m. and lag pump at 1:30 p.m. when the system is off in summer mode.

3.11.10. Main Pump Modulated Flow:

The main heating pump speed (normally controlled by a VFD provided by others) is modulated to maintain the minimum differential pressures of ~~the~~ multiple sensors (where applicable) at the setpoint required for the individual heating loops.

3.11.11. Limits and Safeties:

3.11.11.1. The supply water temperature setpoint is limited to operate between 45 °C and 105 °C.
3.11.11.2. Summer mode delay shutdown. The primary heating pumps have a delay-off time of 5 minutes.
3.11.11.3. Minimum Boiler Runtime with Circulating Pump Interlock: Each boiler must run at least 2 minutes before it will modulate above the minimum firing rate. The boilers cannot modulate up from the minimum fire until the boiler circulating pump status is on.
3.11.11.4. Inter-boiler Runtime Delay: The lead boiler must run at least 5 minutes before the next boiler can start. The delay is increased to 30 minutes when switching from summer to winter operation.

3.11.12. Alarms:

3.11.12.1. Hot water supply temperature too high alarm (triggered above 12 °C deviation from setpoint after a 600 second time delay and restored below 10 °C deviation from setpoint).
3.11.12.2. Hot water supply temperature too low alarm (triggered below -12 °C deviation from setpoint after a 300 second time delay and restored above -10 °C deviation from setpoint). (Alarm is routed to Heat Loss Alarm for notification of security staff).
3.11.12.3. Boiler alarm in an incorrect state (separate alarm for each boiler).

3.11.12.4. Any pump in an incorrect state after a 300 second time delay (separate alarm for each pump).
3.11.12.5. Any VFD alarm (separate alarms for each VFD).
3.11.12.6. Differential water pressure too high alarm (triggered above 5 psi deviation from setpoint after a 600 second delay and restored below 3 psi deviation from setpoint) or too low alarm (triggered below -5 psi deviation from setpoint after a 300 second delay and restored above -3 psi deviation from setpoint) (separate alarm for each differential water pressure).

3.12. Hydronic Heating System with Condensing Boilers Sequence of Operations:

3.12.1. System Enable/Disable Criteria for Winter Mode:
Winter Mode is active between September 16 and May 15.
When Winter Mode is active the heating system is enabled no matter what the outdoor air temperature . A failure of the outdoor air temperature sensor or the networking of it to other controllers does not cause a no-heat condition.
The boilers operate when heating is enabled.
When heating is enabled the lead primary heating pump runs. (See the lead/lag heating pump sequence.)
Once the heating system is enabled, the sequence is followed starting with 3.11.4 Hot Water Supply Setpoint Determination.

3.12.2. System Enable/Disable Criteria for Summer Mode:
Summer Mode is active between May 16 and September 15.
The heating system is enabled when the outdoor air temperature is lower than 4 °C and disabled when the outdoor air temperature goes above 4 °C with a 2 °C deadband.
Once the heating system is enabled, the sequence is followed starting with 3.11.4 Hot Water Supply Setpoint Determination.
When the heating system is disabled in summer mode, the boilers, main and circulation pumps are shut off.
The primary heating pumps have a delay-off time of 5 minutes.

3.12.3. Changeover from Summer to Winter Mode:
Inter-boiler Runtime Delay: The lead boiler must run at least 5 minutes before the next boiler can start.
The delay is increased to 30 minutes when switching from summer to winter operation.

3.12.4. Hot Water Supply Temperature Setpoint Determination
The Hot Water Supply Temperature Setpoint is the sum of the Outdoor Air Temperature Reset calculation and the sum of the applicable offsets based on the current Mode of Operation.
General Equation:
Hot Water Supply Temperature Setpoint = Outdoor Air Temperature Reset Calculation + Return Water Temperature Offset + Morning Warm-Up Offset + Unoccupied Setback Offset + Minimum Zone Temperature Deviation Reset Offset
Resets and Offset Calculations:
Outdoor Air Temperature Reset Calculation: The Hot Water Supply Temperature Setpoint is reset from the outdoor air temperature as per the following linear reset schedule (adjustable):

Oat	HwstSp
16 °C	55 °C
-20 °C	90 °C

Return Water Temperature Offset:
The hot water supply temperature setpoint is further offset +5 °C to maintain boiler entering water below 55 °C to maximize condensation:

Hwrt	HwstSpAdd
52 °C	0 °C
55 °C	-5 °C

Morning Warm-Up Temperature Offset:
The hot water supply temperature setpoint has a +10 °C offset added during morning warm-up mode.
Unoccupied Setback Offset:
The hot water supply temperature setpoint is reduced by -5 °C for unoccupied setback.
Minimum Zone Temperature Deviation Reset Offset:
The hot water supply temperature setpoint is also reset +/- 5 °C based on the minimum zone temperature deviation from setpoint when in Occupied Mode.

3.12.5. Unoccupied Mode:
The heating system is in unoccupied mode when the Time Schedule is not in Occupied or Morning-Warm-Up Mode,

3.12.6. Morning Warm-Up Mode:
During the optimum start, the boiler system system will be in Morning Warm-Up Mode.
The optimized start program, based on outdoor air temperature and time of day schedule, is to begin up to 120 minutes (adjustable) before the occupancy schedule to allow for morning warm up.

The optimized start time is calculated based on how long the hot water supply temperature has historically taken to reach setpoint at the current outdoor air temperature.

3.12.7. Occupied Mode:

The heating system is Occupied Mode as determined by the associated Time Schedule.
Boilers are modulated by the BAS to maintain Hot Water Supply Temperature Setpoint. Boilers are cycled on a call from supply water temperature in sequence to maintain the Hot Water Supply Temperature Setpoint.
The overall heating requirement signal is produced from the output of a heating PID loop %Htg to maintain the supply water temperature at setpoint.

For 2 Modulating Condensing Boilers, as the heating signal increases above the lead boiler start point (initially 30 % ON / 10 % OFF, all setpoints are adjustable), the lead boiler's circulation pump starts.
When this boiler circulation pump's status is verified on for 60 seconds, the lead boiler can start at its lowest output.
The lead boiler output is ramped up and down at 10 % per minute until it reaches 100 % output.
As the heating requirement increases above the lag boiler start point (initially 60 % ON / 50 % OFF), the lag boiler's circulation pump starts.
When this boiler circulation pump's status is verified on for 60 seconds, the lag boiler can start.
When the lag boiler starts, both boilers go to their minimum modulation outputs. They then modulate together, ramped at 10 % per minute from minimum to 100 % with the heating signal.
When the boilers have ramped down to their minimum modulation outputs based on the heating signal demand, and have been there for 60 seconds, the lag boiler is turned off.
The lag boiler circulation pump runs for 5 minutes or until the return and supply boiler water temperatures are within 1 °C of each other and then it shuts off.
The lead boiler then modulates alone (ramped) as required by the heating signal.
When the lead boiler is at minimum modulation output for 60 seconds it is turned off.
The lead boiler circulation pump runs for 5 minutes or until the return and supply boiler water temperatures are within 1 °C of each other and then it shuts off.
For 3 Modulating Condensing Boilers, as the heating signal increases above the lead boiler start point (initially 30 % ON / 10 % OFF, all setpoints are adjustable), the lead boiler's circulation pump starts.
When this boiler circulation pump's status is verified on for 60 seconds, the lead boiler can start at its lowest output.
The lead boiler output is ramped up and down at 10 % per minute until it reaches 100 % output.
As the heating requirement increases above the lag1 boiler start point (initially 60 % ON / 50 % OFF), the lag boiler's circulation pump starts.
When this boiler circulation pump's status is verified on for 60 seconds, the lag1 boiler can start.
When the lag1 boiler starts, both boilers go to their minimum modulation outputs. They then modulate together, ramped at 10 % per minute from minimum to 100 % with the heating signal.
As the heating requirement increases above the lag2 boiler start point (initially 90 % ON / 50 % OFF), the lag2 boiler's circulation pump starts.
When this boiler circulation pump's status is verified on for 60 seconds, the lag2 boiler can start.
When the lag2 boiler starts, the three boilers go to their minimum modulation outputs. They then modulate together, ramped at 10 % per minute from minimum to 100 % with the heating signal.
When the three boilers have ramped down to their minimum modulation outputs based on the heating signal demand, and have been there for 60 seconds, the lag2 boiler is turned off.
The lag2 boiler circulation pump runs for 5 minutes or until the return and supply boiler water temperatures are within 1 °C of each other and then it shuts off.

When the two boilers have ramped down to their minimum modulation outputs based on the heating signal demand, and have been there for 60 seconds, the lag1 boiler is turned off.
The lag1 boiler circulation pump runs for 5 minutes or until the return and supply boiler water temperatures are within 1 °C of each other and then it shuts off.
The lead boiler then modulates alone (ramped) as required by the heating signal.
When the lead boiler is at minimum modulation output for 60 seconds it is turned off.
The lead boiler circulation pump runs for 5 minutes or until the return and supply boiler water temperatures are within 1 °C of each other and then it shuts off.

3.12.8. Lead/Lag Boiler operation:

Provided for boilers on a weekly basis. Typically rotated on a Tuesday at 1:00 p.m. when a new lead boiler is assigned. The next lag boiler is to start should the Lead Boiler fail to start.
The boiler circulating pumps are hard wired by the Mechanical Contractor to the local boiler controls and flow switch(s) so that each boiler starts when the associated pump is confirmed running through the flow switch(s). The boiler circulating pump current draws are monitored by BAS to determine status.

3.12.9. Main Heating Pumps:

One of the main heating pumps will operate continuously when heat is enabled. They operate on a weekly lead/lag operation, typically rotated on a Thursday at 1:00 p.m. when a new lead pump is assigned. (Lag pump starts if lead pump fails or is in alarm mode)

Main heating pumps are monitored by BAS for status.

Main heating pumps are exercised to run for 10 minutes once a week, typically lead pump on a Thursday at 1:00 p.m. and lag pump at 1:30 p.m. when the system is off in summer mode.

3.12.10. Main Pump Modulated Flow:

The main heating pump speed (normally controlled by a VFD provided by others) is modulated to maintain the minimum differential pressures of ~~the~~ multiple sensors (where applicable) at the setpoint required for the individual heating loops.

3.12.11. Limits and Safeties:

3.12.11.1. The supply water temperature setpoint is limited to operate between 45 °C and 95 °C. (As per boiler specifications)

3.12.11.2. Summer mode delay shutdown. The primary heating pumps have a delay-off time of 5 minutes.

3.12.11.3. Minimum Boiler Runtime with Circulating Pump Interlock: Each boiler must run at least 2 minutes before it will modulate above the minimum firing rate. The boilers cannot modulate up from the minimum fire until the boiler circulating pump status is on.

3.12.11.4. Inter-boiler Runtime Delay: The lead boiler must run at least 5 minutes before the next boiler can start. The delay is increased to 30 minutes when switching from summer to winter operation.

3.12.12. Alarms:

3.12.12.1. Hot water supply temperature too high alarm (triggered above 12 °C deviation from setpoint after a 600 second time delay and restored below 10 °C deviation from setpoint).

3.12.12.2. Hot water supply temperature too low alarm (triggered below -12 °C deviation from setpoint after a 300 second time delay and restored above -10 °C deviation from setpoint). (Alarm is routed to Heat Loss Alarm for notification of security staff).

3.12.12.3. Boiler alarm in an incorrect state (separate alarm for each boiler).

3.12.12.4. Any pump in an incorrect state after a 300 second time delay (separate alarm for each pump).

3.12.12.5. Any VFD alarm (separate alarms for each VFD).

3.12.12.6. Differential water pressure too high alarm (triggered above 5 psi deviation from setpoint after a 600 second delay and restored below 3 psi deviation from setpoint) or too low alarm (triggered below -5 psi deviation from setpoint after a 300 second delay and restored above -3 psi deviation from setpoint) (separate alarm for each differential pressure sensor).

3.13. Hydronic Heating Control Valves Sequence of Operations:

When a hydronic hot water wall fin/convectors, radiant panels, or similar perimeter heat serves a room that is also served by an associated fan system/rooftop unit, the hot water perimeter heat is to be sequenced (where appropriate) as the first stage of heating for each applicable zone.

The space sensor PID controller modulates the perimeter heat control valve as a first stage of heating for each applicable zone to maintain setpoint.

3.13.1. Hot Water Wall Fin / Convectors / Radiant Panels

Non adjustable space temperature plate sensor or room temperature sensor with local setpoint adjust and pushbutton override is provided where indicated.

3.13.1.1. Perimeter Convector Heaters

Space sensor modulates the valve for heating to maintain room temperature setpoint, which is reduced during unoccupied hours.

Space sensor is used as low temperature alarm

3.13.1.2. Cabinet Unit Heaters

Space sensor cycles unit heater for heating to maintain setpoint.

Space sensor is used as low temperature alarm

3.13.1.3. Limits and Safeties

Hydronic heating control valves are to fail open to heat.

3.13.1.4. Alarms

An alarm is generated at the BAS when:

The space temperature is too low alarm (triggered below 14 °C and restored above 16 °C)

The space temperature is too high alarm (triggered above 38 °C and restored below 36 °C)

Low temperature alarm to be integrated through security to On-Call Response

3.14. In-Floor Hydronic Slab Heating Sequence of Operations:

The two-way in-floor heating valve(s) are cycled by the slab temperature sensor to maintain slab temperature setpoint which is reset from the outside air temperature and offset by the minimum room temperature reading of the associated zone heating wall temperature sensor(s) as follows:

The outside air temperature resets the slab temperature setpoint on a linear setting

Outside Air Temperature	Slab Temp Setpoint resets to
5 °C or lower	27 °C
16 °C or higher	22 °C

The minimum room temperature provides an offset to the slab temperature setpoint on a linear setting

Minimum Room Temperature	Slab Temp Setpoint Offset
18°C	0 °C
23°C	-2 °C

Limits and Safeties

In-floor slab hydronic heating is disabled when the Heating Enable Mode is disabled.

3.14.1. Alarms

An alarm is generated at the BAS when:
The space temperature is too low (triggered below 14 °C and restored above 16 °C). Low temperature alarm to be integrated through Security to On-Call Response
The space temperature is too high alarm (triggered above 38 °C and restored below 36 °C)
The slab temperature is too high alarm (triggered above 32 °C and restored below 30 °C)

3.15. Chilled Water Cooling Coils Sequence of Operations: Unoccupied Mode

The cooling coil valve is closed. There can be no unoccupied cooling.

3.15.1. Occupied Mode

The cooling coil valve modulates open when there is chilled water in the CW mains.

3.15.2. Limits and Safeties:

Cooling valves are closed when the outside air temperature is below the global cooling disable setpoint or the CW mains temperature is above 20°C.

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3.16. Cooling Tower with Heat Pump Loop - Sequence of Operations:

3.16.1. Cooling Tower Disabled Mode

Cooling Tower Pump is disabled when the outdoor air temperature is below 5 °C.

3.16.2. Cooling Tower Enabled Mode

Cooling Tower Pump is enabled when the outdoor air temperature is above 6 °C.
Heat Pump Loop Supply Water Temperature Sensor controls two stages of cooling and modulates the heating valve in sequence to maintain the Heat Pump Loop Supply Water Temperature setpoint.

3.16.3. Heating Mode:

Heat Exchanger Circulating Pump turns on when Heat Pump Loop Supply Water Temperature drops below 17 °C and Heat Exchanger Valve modulates to maintain 17 °C Heat Pump Loop Supply Water Temperature.

3.16.4. Cooling Mode:

3.16.4.1. As the Heat Pump Loop Supply Water Temperature rises from 17 °C to 20 °C the Heat Exchanger Valve modulates closed to heating and the Heat Exchanger Circulating Pump stops.

3.16.4.2. As the Heat Pump Loop Supply Water Temperature rises from 22 °C to 23.5 °C Cooling Tower discharge damper opens and spray pump starts with 10 second delay ON.

3.16.4.3. As the Heat Pump Loop Supply Water Temperature rises from 26 °C to 28 °C Cooling Tower fan is enabled with 10 second delay ON. Actual start/stop of the Cooling Tower fan is controlled by the discharge damper controller.

3.16.5. Lead/Lag Control is provided for the two Heat Pump Loop Pumps on a weekly basis. If the flow switch indicates no flow, both Heat Pump Loop Pumps will run (resets every 4 hours).

3.16.6. Indication is provided for heat exchanger entering and leaving water temperature, Heat Pump Loop Return Water temperature and Cooling Tower leaving water temperature.

3.16.7. Cooling Tower pump(s) are exercised to run for 5 minutes once a week, typically lead pump on a Thursday at 1:00 p.m. and lag pump at 1:30 p.m. when the Cooling Tower is enabled. (Chemical tower basin chemical agitation)

3.16.8. Limits and Safeties

3.16.8.1. Each output has a time delay-on of 10 to 20 seconds to prevent all equipment from starting at once.

3.16.8.2. One loop pump is wired to fail on the ‘on’ position.

3.16.8.3. The cooling tower pump is disabled when the outdoor air temperature is disabled below 5 °C and enabled above 6 °C.

3.16.8.4. The cooling tower fan has a minimum off-time of 90 seconds.
3.16.8.5. The cooling tower fan cannot start unless the discharge damper end switch is closed.
3.16.8.6. If the Heat Pump Loop supply water temperature and Heat Pump Loop return water temperature are out of range (for 4 minutes), all heat pumps stop and an alarm is generated at the BAS.

3.16.9. Alarms
3.16.9.1. Any Heating Loop Pump in incorrect mode.
3.16.9.2. Any Cooling Loop Pump in incorrect mode.
3.16.9.3. Low boiler supply water temperature alarm (triggered below 20 °C and restored above 25 °C, disabled when boiler is shut off).
3.16.9.4. High boiler supply water temperature alarm (triggered above 95 °C and restored below 93 °C).
3.16.9.5. Low boiler return water temperature alarm (triggered below 20 °C and restored above 25 °C, disabled when boiler is shut off).
3.16.9.6. High boiler return water temperature alarm (triggered above 92 °C and restored below 90 °C).
3.16.9.7. Cooling tower fan in incorrect mode.
3.16.9.8. Low Heat Pump Loop return water temperature alarm (triggered below 15 °C and restored above 16 °C) or high Heat Pump Loop return water alarm (triggered above 34 °C and restored below 33 °C).
3.16.9.9. Low Heat Pump Loop supply water temperature alarm (triggered below 15 °C and restored above 16 °C) or high Heat Pump Loop supply water temperature alarm (triggered above 34 °C and restored below 33 °C).
3.16.9.10. No flow in loop.
3.16.9.11. Cooling tower damper in the wrong position.

3.17. Condenser Water Cooling Tower with Chiller System Sequence of Operations:

3.18. Cooling Tower Disabled Mode
Cooling Tower Pump is disabled when the outdoor air temperature is below 5 °C.
3.18.1. Cooling Tower Enabled Mode
Cooling Tower Pump is enabled when the outdoor air temperature is above 6 °C.
3.18.1.1. On a call for cooling, the following sequence occurs: the chilled water pump starts and 30 seconds later the condenser water pump starts and when the pump statuses are confirmed on, the chiller starts.
3.18.1.2. Condenser water temperature sensor (entering chiller) cycles the cooling tower fan to maintain setpoint. (typically 27 °C)
3.18.2. Condenser water pump is exercised to run for 5 minutes once a week, typically lead pump on a Thursday at 1:00 p.m. to 1:30 p.m. when the system is on in summer mode. (Chemical tower basin chemical agitation).

3.18.3. Limits and Safeties
3.18.3.1. Each output has a time delay-on of 10 to 20 seconds to prevent all equipment from starting at once.
3.18.3.2. One loop pump is wired to fail on the ‘on’ position.
3.18.3.3. The Chilled water system is disabled when the outdoor air temperature falls 2 °C below Global Mechanical Cooling Enable Setpoint.
3.18.3.4. If the chilled supply water temperature and return water temperature are out of range (for 4 minutes), an alarm is generated at the BAS

3.18.4. Alarms
3.18.4.1. Condenser water pump and/or cooling tower fan in incorrect mode.
3.18.4.2. Condenser entering temp. too low (-6/-6°C dev. from setpoint, 300s delay) or too high (6/5°C dev. from setpoint, 300s delay).
3.18.4.3. Chiller fault.

3.19. Chilled Water Cooling System Sequence of Operations:

3.20. Chiller Disabled Mode
Chiller is disabled when the outdoor air temperature is below 16 °C (adjustable).

3.21. Chiller Enabled Mode:
3.21.1. Interlock cooling enable mode with heating enable mode to ensure no simultaneous heating and cooling.
3.21.2. When the chiller is enabled, chilled water pumps run continuously. The lead chilled water pump speed is modulated to maintain the differential water pressure at setpoint. This setpoint is automatically adjusted during the day to maintain the control valve on the loop with the greatest demand at the near open to minimize pump energy. The chilled water supply sensor modulates the chiller to maintain the supply water temperature setpoint which is reset from the outdoor air temperature as follows:

OAT	CWST
20 °C	11 °C
30 °C	6 °C

3.21.3. Main Chilled Water Pumps:

One of the main chilled water pumps operates continuously when mechanical cooling is enabled. They operate on a weekly lead/lag operation, typically rotated on a Thursday at 1:00 p.m. when a new lead pump is assigned. (Lag pump starts if lead pump fails or is in alarm mode)
Main chilled water pumps are monitored by BAS for status.
Main chilled water pumps are exercised to run for 10 minutes once a week, typically lead pump on a Thursday at 1:00 p.m. and lag pump at 1:30 p.m. when the system is off in winter mode (for pump and valve exercising). Not applicable if systems are drained.

3.21.4. Main Pump Modulated Flow:
The main chilled water pump speed (normally controlled by a VFD provided by others) is modulated to maintain the minimum differential pressures of multiple sensors (where applicable) at the setpoint required for the individual chilled water loops.

3.22. Limits and Safeties:
3.22.1. The chillers are enabled when the outdoor air temperature is greater than 16 °C for 60 minutes.
3.22.2. The enable temperature is reset up to 20 °C as the outdoor relative humidity falls from 50 %RH to 30 %RH.
3.22.3. Between September 15 and May 15, the chiller enable temperature is 22 °C.
3.22.4. The pumps delay off 5 minutes after the chiller is shut off.

3.23. Alarms:
3.23.1. Chilled water supply temperature too high alarm (triggered above 13 °C and restored below 11 °C) or too low alarm (triggered below 4 °C and restored above 6 °C) when chillers have been enabled for at least 30 minutes.
3.23.2. Chiller Alarm
3.23.3. Any chilled water pump is in an incorrect state or VFD alarm.
3.23.4. Differential water pressure too high alarm (triggered above 5 psi above setpoint and restored 3 psi below setpoint) for 10 minutes.

3.24. Chilled Water Cooling Coils Sequence of Operations:Unoccupied Mode

The cooling coil valve is closed. There can be no unoccupied cooling.
3.24.1. Occupied Mode
The cooling coil valve modulates open when there is chilled water in the CW mains.
3.24.2. Limits and Safeties:
Cooling valves are closed when the outside air temperature is below the global cooling disable setpoint or the CW mains temperature is above 20°C.
3.24.3. Alarms
3.24.3.1. 1) Space temperature too high (triggered above 38 °C and restored below 36 °C) or too low (triggered below 14 °C and restored above 15 °C)

3.25. Ductless Split - Cooling Only Unit Sequence of Operations:

3.25.1. Unoccupied Mode
The system is off. If the pushbutton on the room sensor is pressed, the system will switch to the occupied mode for a period of 2 hours (adjustable).
3.25.2. Occupied Mode
The room temperature sensor cycles the ductless split to maintain the occupied cooling setpoint. Setpoint adjustment of +/-1 °C is provided. The unit is disabled when the outside air temperature is below the global mechanical cooling disable setpoint (initially disabled below 12 °C and enabled above 14 °C).
3.25.3. Limits and Safeties:
3.25.3.1. The cooling mode is disabled when heating mode is enabled and when the Outside Air Temperature is below the global mechanical cooling disable setpoint (initially disabled below 16 °C and enabled above 18 °C).
3.25.3.2. A minimum off-time of 5 minutes is provided.
3.25.3.3. Cooling setpoint is limited to a minimum of 23.5 °C.
3.25.4. Alarms
3.25.4.1. An alarm is generated at the BAS if the room temperature is too cold (triggered below 14 °C and restored above 15 °C) or too hot (triggered above 36 °C and restored below 35 °C).
3.25.4.2. The fan status does not match the start/stop point.
3.25.4.3. Weekly fan runtime limit exceeded.

3.26. Ductless Split - Heat Pump Sequence of Operations:

3.26.1. Unoccupied Mode
The system is off. If the pushbutton on the room sensor is pressed, the system will switch to the occupied mode for a period of 2 hours (adjustable).

3.26.2. Occupied Mode

The room temperature sensor cycles the ductless split heat pump to maintain the occupied cooling setpoint (typically 24.5 °C) or occupied heating setpoint (typically 21.5 °C). Where applicable, the heat pump is to be the first stage of heating. Setpoint adjustment of +/-1 °C is provided.

3.26.3. Limits and Safeties:

3.26.3.1. The cooling mode is disabled when heating mode is enabled and when the Outside Air Temperature is below the global mechanical cooling disable setpoint (initially dIsabled below 16 °C and enabled above 18 °C).

3.26.3.2. The heating mode is disabled when cooling mode is enabled and when the Outside Air Temperature is above the global heating disable setpoint (initially dIsabled above 14 °C and enabled below 12 °C).

3.26.3.3. A minimum off-time of 5 minutes is provided.

3.26.3.4. Heat pump is disabled if the condensate pump fails. Hard-wired into the condensate pump safeties switch.

3.26.3.5. Cooling setpoint is limited to a minimum of 23.5 °C.

3.26.3.6. Heating setpoint is limited to a maximum of 22 °C.

3.26.3.7. Heat Pump heat mode is disabled when Outside Air Temperature is below 5 °C.

3.26.4. Alarms

An alarm is generated at the BAS if:

3.26.4.1. The room temperature is too cold (triggered below 14 °C and restored above 15 °C) or too hot (triggered above 36 °C and restored below 35 °C).

3.26.4.2. The heat pump fan status does not match the start/stop point.

3.26.4.3. Weekly fan runtime limit exceeded.

3.27. Water to Air Heat Pump Unit Sequence of Operations:

3.27.1. Discretionary Fire Alarm Shutdown Mode:

The supply fan is off, heating is disabled and cooling is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal Heat Pump Unit functions are auto restored on relay signal from the fire alarm panel reset.

3.27.2. Software Freeze-stat Shutdown Mode:

The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 30 seconds, restored above 5 °C after 5 minutes, and auto reset after 5 minute delay).

3.27.3. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.27.3.1. (Idle State)

The supply fan is off, heating is disabled and cooling is disabled.

3.27.3.2. (Unoccupied Heating State)

System cycles on a call for unoccupied heating. A full call for heating until setpoint is reached.
Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C OAT or lower and 18.0 °C at -20.0 °C OAT or lower (each adjustable)
Mechanical Cooling: Disabled

3.27.3.3. (Push Button Override State)

If the override pushbutton is pressed, at any room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation and cooling enabled.

3.27.4. Morning Warmup Mode:

An optimized start, based on the time of day schedule of the associated Make Up Air Unit, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The supply fan is on, heating is enabled at full capacity and the cooling is disabled.
The optimized start program is to begin up to 105 minutes before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.

3.27.5. Occupied Mode:

Time of day schedule, which starts the associated Make Up Air unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
Heat Pump fan status confirmed by current sensing device(s).
Fan operation: The supply fan runs continuously.
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Free Cooling Enabled temperature setpoint nominal 22.5 °C +/-1.0 °C
Room mechanical cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)

3.27.6. Standby Occupancy Mode:
Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.
Minimum outdoor air is set to zero when the global ventilation schedule is off).
Fan operation: Supply fan and return fan (where applicable) runs only on a call from heating or cooling only.
Ventilation normally set to zero (with a future provision to adjust).
Room heating temperature setpoint nominal: 21.5 °C +/- 1.0 °C (adjustable)
Room Mechanical Cooling temperature setpoint nominal 24.5 °C +/- 1.0 °C (adjustable)
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.27.7. Heating Sequence:
3.27.7.1. Outdoor Air Temperature used to determine Heating Enable Mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.
3.27.7.2. Default Setpoint:
When the Heating Mode is active, the default room temperature setpoint remains unchanged.
3.27.7.3. Call for Heating:
Heat pump is used for heating until the heating calls (from room controller PID or Night Setback thresholds) are satisfied.
Radiation Zone
Where there is a zone served by radiation, the radiation valve opens (where applicable) and is to be the second stage of heat.

3.27.8. Cooling Sequence:
3.27.8.1. Outdoor Air temperature used to determine cooling enable mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.
3.27.8.2. Default Cooling Setpoint:
When the cooling enable mode is active, the default room temperature setpoint is raised by 3°C.
3.27.8.3. Call for Cooling:
Mechanical cooling will be used until the cooling calls (from room controller PID) are satisfied.

3.27.9. Limits and Safeties:
3.27.9.1. The supply fan has a delay-off time of 90 seconds.
3.27.9.2. The heat pump cooling has a minimum-off time of 5 minutes.
3.27.9.3. Lock out operation of the heat pump if the associated water loop temperature is out of range.
.
3.27.10. Alarms:
An alarm will be generated upon the following conditions:
3.27.10.1. Fan status does not match the start/stop signal.
3.27.10.2. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).
3.27.10.3. Space temperature too high alarm (triggered above 38°C and restored above 36°C).
3.27.10.4. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C).
3.27.10.5. Heat pump fault
3.27.10.6. Weekly fan runtime limit exceeded
3.27.10.7. Lock out operation of the heat pump if the associated water loop temperature is out of range. (triggered above 34 °C and restored below 33 °C, triggered below 15 °C and restored above 16 °C)

3.28. Electric Heat Sequence of Operation

3.28.1. Stairwells and Vestibules:
3.28.1.1. Heating Disabled:
During Occupied Hours as set by the associated time schedule, heating is disabled when either the Outdoor Air Temperature above 12 °C or Vestibule Air Temperature above 18 °C are exceeded.
During Unoccupied Hours as set by the associated time schedule, heating is disabled when either the Outdoor Air Temperature is above 5 °C or Vestibule Air Temperature is above 17 °C are exceeded.
3.28.1.2. Heating Enabled:
During Occupied Hours as set by the associated time schedule, heating is enabled when both the Outdoor Air Temperature below 10 °C and Vestibule Air Temperature above 16 °C.

During Unoccupied Hours as set by the associated time schedule, heating is enabled when both the Outdoor Air Temperature below 0 °C and Vestibule Air Temperature below 16 °C.

3.28.1.3. Limits and Safeties:
1) Electric vestibule heaters are disabled when outside temperature threshold(s) are exceeded.
2) Electric vestibule heaters are disabled when room temperature threshold(s) are exceeded.

3.28.1.4. Alarms:
1) Electric vestibule temperature too low or too high.

3.28.2.

Utility Spaces:

3.28.2.1. Heating Disabled:
Heating is disabled when either the Outdoor Air Temperature above 12 °C or Vestibule Air Temperature above 18 °C are exceeded.

3.28.2.2. Heating Enabled:
Heating is enabled when both the Outdoor Air Temperature below 10 °C and Vestibule Air Temperature above 16 °C.

3.28.2.3. Limits and Safeties:
1) Electric heaters are disabled when outside temperature threshold(s) are exceeded.
2) Electric heaters are disabled when room temperature threshold(s) are exceeded.

3.28.2.4. Alarms:
1) Space temperature is too low or too high.

3.29. Fan Coil Units (Hydronic)

3.29.1. Unoccupied Mode
Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.29.2. (Idle State)
The supply fan is off, heating is off.

3.29.2.1. (Unoccupied Heating State)

3.29.2.2. System cycles on a call for unoccupied heating. A full call for (full heat modulation where applicable) heating until setpoint is reached.

3.29.2.3. (Push Button Override State)
The system is off. If the pushbutton (where applicable) on the room sensor is pressed, the system will switch to the occupied mode for a period of 2 hours (adjustable).

3.29.3. Occupied Mode

3.29.4. Heating Sequence:

3.29.4.1. Outdoor Air Temperature used to determine Heating Enable Mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.29.4.2. Default Setpoint:
When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.29.4.3. Call for Heating:

3.29.4.4. Heating or cooling mode is decided upon available water temperature.

3.29.4.5. Heating mode is when the water temperature is above the room temperature.
Mechanical heating is cycled on until the heating calls (from room controller PID or Night Setback thresholds) are satisfied.

3.29.5. Setpoint adjustment of +/- 1 °C is provided. (where applicable)

3.29.6. Cooling Sequence:

3.29.6.1. Outdoor Air Temperature used to determine Cooling Enable Mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature above the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 5 °C from September to May and 16 °C from June to August.

3.29.6.2. Default Setpoint:
When the Cooling Mode is active, the default room temperature setpoint remains unchanged.

3.29.6.3. Call for Cooling:

3.29.6.4. Cooling mode is decided upon available water temperature.

3.29.6.5. Cooling mode is when the water temperature is below the room temperature.
Mechanical cooling is used until the cooling calls (from room controller PID or Night Setback thresholds) are satisfied.

3.29.7. Setpoint adjustment of +/- 1 °C is provided. (where applicable)

3.29.8. Limits & Safeties

3.29.8.1. Heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.29.9. A minimum off-time of 5 minutes is provided.

3.29.10. Alarms

An alarm will be generated upon the following conditions:

3.29.10.1. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C).

3.29.10.2. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.30. Electric Force Flow Heater for Occupied Spaces Sequence of Operations:

3.30.1.1. Heating Disabled:

During Occupied Hours as set by the associated time schedule, heating is disabled when either the Outdoor Air Temperature above 12 °C or Space Air Temperature above 21 °C are exceeded.

During Unoccupied Hours as set by the associated time schedule, heating is disabled when either the Outdoor Air Temperature is above 5 °C or Space Air Temperature is above 19 °C are exceeded.

3.30.1.2. Heating Enabled:

During Occupied Hours as set by the associated time schedule, heating is enabled when both the Outdoor Air Temperature below 10 °C and Space Air Temperature above 21 °C.

During Unoccupied Hours as set by the associated time schedule, heating is enabled when both the Outdoor Air Temperature below 0 °C and Space Air Temperature below 19 °C.

3.30.1.3. Limits and Safeties:

1) Electric Space heaters are disabled when outside temperature threshold(s) are exceeded.

2) Electric Space heaters are disabled when room temperature threshold(s) are exceeded.

3.30.1.4. Alarms:

1) Electric Space temperature is too low or too high.

3.31. Exhaust Fan Sequence of Operations:

General and Washroom Exhaust Fans

3.31.1. Discretionary Fire Alarm Shutdown Mode:

The Exhaust Fan is off. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code.

Normal Exhaust Fan function is auto restored on relay signal from the fire alarm panel reset.

3.31.2. Unoccupied Mode:

Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.

The system will be in Unoccupied Mode when not in Occupied by modes.

3.31.2.1. (Idle State)

The exhaust fan is off.position.

3.31.3. Occupied Mode:

Time of day schedule, which starts the Exhaust Fan unit(s) usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule or Unoccupied Mode.

Exhaust Fan status confirmed by current sensing device(s) or VFD feedback.

Fan operation: The Exhaust Fan runs continuously.

3.31.4. Limits and Safeties:

3.31.4.1. The Exhaust fan has a delay-off time of 90 seconds.

3.31.4.2. The start times are staggered across a group of Exhaust Fans.

3.31.5. Alarms:

An alarm will be generated upon the following conditions:

3.31.5.1. Fan status does not match the start/stop signal.

3.31.5.2. Weekly fan runtime limit exceeded.

3.32. Science Prep / Classroom Fume Hood Sequence of Operations:

3.32.1. Fume Hood in Use Mode:

The BAS provides AUTO/ENABLE with a manual operator's Start/Stop switch control of the fume hood exhaust fan according to a time schedule.

Fan status (where applicable) is monitored by a current sensor.

When the fan status is on, the return air dampers close to a position as determined by the air balancer (mechanical stop).

If the fume hood fan is running when the associated rooftop unit is off, the transfer damper (where applicable) opens to provide air from the room.

3.32.2. Limits and Safeties:

3.32.2.1. The BAS system cycles the fan every 6 hours for 30 minutes (auto-flush).
Typically auto-flushes at 6:00 a.m. noon, 6:00 p.m. and midnight.
Alarms:
An alarm will be generated upon the following conditions:

3.32.2.2. Fan status does not match the start/stop signal.

3.32.2.3. Weekly fan runtime limit exceeded.

3.33. Kitchen Exhaust Hood Fan Sequence of Operations:

3.33.1. Occupied Mode:
The BAS provides AUTO/ENABLE with a manual operator's Start/Stop switch control of the Kitchen Exhaust hood fan according to a time schedule.
Fan status is monitored by a current sensor.

3.33.2. Unoccupied Mode:
Kitchen Exhaust Hood Fan is off.

3.33.3. Limits and Safeties:

3.33.3.1. When the fan hood is running and the DX cooling (where applicable) is on, the associated supply air system is locked off.

3.33.3.2. When the fan status is on, the return air dampers (where applicable) close to a position as determined by the air balancer (mechanical stop).

3.33.4. Alarms:
An alarm will be generated upon the following conditions:

3.33.4.1. Fan status does not match the start/stop signal.

3.33.4.2. Weekly fan runtime limit exceeded.

3.34. Make Up Air Unit Sequence of Operations:

3.34.1. Discretionary Fire Alarm Shutdown Mode:
The supply fan is off, the outdoor air dampers are in the 0% outdoor air position, heating is disabled and cooling (where applicable) is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal HVAC unit functions are auto restored on relay signal from the fire alarm panel reset.

3.34.2. Software Freeze-stat Shutdown Mode:
The duct/unit mounted supply air temperature sensor acts as a software freeze-stat (triggered below 1 °C after 3 minutes, restored above 5 °C after 3 minutes).

3.34.3. Unoccupied Mode:
Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.34.3.1. (Idle State)
The supply fan is off, the Global Ventilation Schedule is disabled, the outdoor air dampers are in the 0 % outdoor air position, heating is disabled and cooling (where applicable) is disabled.

3.34.3.2. (Unoccupied Heating State)
Applicable where reheat coils are used. Not applicable if fan-forced reheat coils are used.
System does not cycle on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Mechanical Cooling: Disabled
Free Cooling: Disabled
Global Ventilation Schedule: Disabled

3.34.3.3. (Push Button Override State)
Applicable where reheat coils are used. Not applicable if fan-forced reheat coils are used.
If the override pushbutton is pressed, at any room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable). With outdoor air ventilation and cooling enabled.

3.34.4. Morning Warmup Mode:
Applicable where reheat coils are used. Not applicable if fan-forced reheat coils are used.
An optimized start, based on the time of day schedule, outdoor air temperature and the lowest indoor zone temperature is provided for heating.
The Global Ventilation Schedule is disabled. The supply fan is on, the exhaust fan is on (where applicable), the outdoor air dampers are in the 0 % outdoor air position, heating is enabled at full capacity and the cooling is disabled.
The optimized start program is to begin up to 105 minutes before the occupancy schedule to allow for morning warm up to bring the lowest zone temperature up to occupancy setpoint.

3.34.5. Occupied Mode:
Time of day schedule, which starts the Make Up Air Unit along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Global Ventilation Schedule is enabled.
HVAC unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan and exhaust fan (where applicable) run continuously.
Global Ventilation Schedule: Enabled

3.34.6. Standby Occupancy Mode:
Not applicable.

3.34.7. Ventilation Lockout (Sequence):
When the ventilation lockout switch, usually located in the Custodial Office, is engaged, Make Up Air Unit is disabled.
When the ventilation lockout switch is disengaged, systems return to mode of operation based on the time of day schedule.

3.34.8. Supply Air Temperature Setpoint:
The Supply Air Temperature Setpoint is reset between 13 °C to 18 °C as the outside air temperature falls from 10 °C to -15 °C.
The Supply Air Temperature Setpoint is limited to a range of 12 °C to 20 °C.

3.34.9. Heating Sequence:

3.34.9.1. Outdoor Air Temperature used to determine Heating Enable Mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the heating enable mode based on the outdoor air temperature below the threshold. The threshold is further adjusted by a calendar schedule.
Typical default values are: 16 °C from September to May and 5 °C from June to August.

3.34.9.2. Default Supply Air Temperature Setpoint:
Make Up Air Unit cooling is controlled from the supply air temperature sensor.

3.34.9.3. Call for Heating:
Mechanical (gas fired) heating is used until the heating calls (from supply air temperature controller PID or Night Setback thresholds) are satisfied.
Hydronic
For Heating Valve, (where applicable) 0 % signal (10 Volts) closes the heating valve. A 100% signal (below 2 Volts) opens the heating valve.

3.34.10. Cooling Sequence:

3.34.10.1. Outdoor Air temperature used to determine cooling enable mode:
A set of thresholds that are user adjustable at a global (board wide) or local (site specific) level, triggers the cooling enable mode based on the outdoor air temperature exceeding the threshold. The threshold is further adjusted by a calendar schedule.Typical default values are: 18 °C from September to May and 21 °C from June to August.

3.34.10.2. Default Supply Air Temperature Cooling Setpoint:
Make Up Air Unit cooling is controlled from the supply air temperature sensor.

3.34.10.3. Call for Cooling:
Mechanical cooling will be used until the cooling calls (from supply air temperature controller PID) are satisfied.

3.34.11. Limits and Safeties:

3.34.11.1. The duct mounted supply air temperature sensor acts as a high limit for each stage of heating (for stage 1: disable above 60°C , and enable below 50°C, for stage 2: disable above 55°C and enable below 45°C) and a low limit for each stage of cooling (for stage 1: disable DX1 below 5°C and enable DX1 above 10 °C, for stage 2: below 8 °C disable DX2 and above 13°C enable DX2).

3.34.11.2. The supply air temperature sensor acts as a software freezestat (triggered below 1 °C for 1 minute, restored above 5 °C for 1 minute).

3.34.11.3. The supply fan has a delay-off time of 90 seconds.

3.34.11.4. The DX cooling has a minimum-off time of 5 minutes.

3.34.11.5. DX cooling is disabled when the outdoor air temperature is below global DX disable setpoint (typically 2 °C below Cooling Enable setpoint) or when fan is off.

3.34.11.6. Gas heating is disabled when the outdoor air temperature is above the global heating disable setpoint (typically 2 °C above Heating Enable setpoint) or when the fan is off.

3.34.11.7. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.34.11.8. When the ventilation lockout switch (usually located at the custodial office) is engaged, the Make Up Air Unit is disabled.

3.34.11.9. Cooling cannot turn on until heating has been off for a minimum of 5 minutes.

3.34.11.10. During Occupied Mode, and the outdoor air is above -1°C, heating stage 2 (where applicable) has a delay-on time of 15 minutes, except when the outdoor air temperature is below -3°C with a +2°C deadband.

3.34.12. Alarms:
An alarm will be generated upon the following conditions:

3.34.12.1. Fan status does not match the start/stop signal.

3.34.12.2. Supply air temperature too high alarm (triggered above 65 °C and restored below 63 °C) or too low alarm (triggered below 5 °C and restored above 7 °C).

3.34.12.3. Weekly fan runtime limit exceeded.

3.34.12.4. Software freezestat tripped.

3.35. Furnace Sequence of Operation:

Serving internal spaces like gym storage rooms. Uses return air only, no outside air ductwork. Supply air sensor to be used for indication. BAS enables the furnace through built-in Furnace controllers.

3.35.1. Discretionary Fire Alarm Shutdown Mode:
The furnace is disabled. This is not intended to replace the hard-wired fan shutdown provided by others when required by Code. Normal Furnace unit functions are auto restored on relay signal from the fire alarm panel reset.

3.35.2. Unoccupied Mode:
Mode is active usually between 11:00 p.m. to 7:00 a.m. Monday to Friday and 24 hours Saturday and Sunday.
The system will be in Unoccupied Mode when not in Morning Warmup, Occupied or Standby modes. The system will cycle between Idle State, Heating State or Pushbutton Override States to meet the demands from each state and return to the Idle State when the demands are satisfied.

3.35.2.1. (Idle State)
The furnace is disabled.

3.35.2.2. (Unoccupied Heating State)
System cycles on a call for unoccupied heating. A full call for (all stages or full heat modulation where applicable) heating until setpoint is reached.
Heating temperature nominally 16.0 °C space temperature setpoint with an increased space temperature setpoint to 17.0 °C at -10.0 °C OAT or lower and 18.0 °C at -20.0 °C OAT or lower (each adjustable)

3.35.3. (Push Button Override State)
If the override pushbutton (where applicable) is pressed, at any room sensor, the associated system will switch to the Occupied Mode for 2 hours (adjustable).

3.35.4. Occupied Mode:
Time of day schedule, which starts the HVAC unit(s) along with an Optimum Start program usually between 7:00 a.m. and 4:00 p.m. Monday to Friday, when not overridden by a Holiday Schedule, Standby Occupancy Mode or Unoccupied Mode.
Furnace unit fan status confirmed by current sensing device(s) or VFD feedback.
Fan operation: The supply fan runs continuously.
Room heating temperature setpoint nominal: 19 °C +/- 1.0 °C (adjustable)

3.35.5. Standby Occupancy Mode:
Time of day schedule starts the HVAC unit(s) usually between 4:00 p.m. and 11:00 p.m. Monday to Friday.

Furnace operation: Furnace runs only on a call from heating or cooling only.
Room heating temperature setpoint nominal: 18 °C +/- 1.0 °C (adjustable)

3.35.6. Heating Sequence:

3.35.6.1. Outdoor Air Temperature used to determine Heating Enable Mode:
If the outdoor air temperature is above Global Heating Enable Setpoint the unit is disabled.

3.35.6.2. Default Setpoint:
When the Heating Mode is active, the default room temperature setpoint remains unchanged.

3.35.6.3. Call for Heating:
Mechanical heating (single stage gas heating) is used until the heating calls (from room controller PID or Night Setback thresholds) are satisfied.

3.35.7. Limits and Safeties:

3.35.7.1. The supply fan has a delay-off time of 90 seconds.

3.35.7.2. Stage 1 gas heating (where applicable for units with multiple stages of heating) has a minimum run time of 3 minutes.

3.35.8. Alarms:
An alarm will be generated upon the following conditions:

3.35.8.1. Fan status does not match the start/stop signal.

3.35.8.2. Space temperature too high alarm (triggered above 42 °C and restored below 40 °C) for non-cooling systems, (triggered above 38°C and restored above 36°C) for cooling systems.

3.35.8.3. Space temperature too low alarm (triggered below 14 °C and restored above 16 °C).

3.35.8.4. Weekly fan runtime limit exceeded.

3.36. Destratification Fans Sequence of Operation: (Library/Gyms/Atrium)

Destratification Fans to be controlled by integral controls provided with fan packages (no BAS controls are anticipated).

3.37. Exterior Lighting Sequence of Operation:

3.37.1. Exterior Building Lights

The lights operate according to the time schedule. Lights are disabled between dawn and dusk, as calculated by a software astronomical timer. The following astronomical clock program for exterior lighting is in effect 7 days a week, at all schools, with the exception of schools with vandalism concerns.

September – June: On: 5:45 a.m. Off: At Dawn On: At Dusk Off: 11:45 p.m.
July and August: Exterior Lights Off

3.37.2. Parking Lot Lights

Where applicable, parking lot lighting should be zoned and scheduled separately from exterior building lighting. The lights operate according to the time schedule. Lights are disabled between sunrise and sunset, as calculated by a software astronomical timer. The following astronomical clock program for exterior lighting is in effect 7 days a week, at all schools, with the exception of schools with vandalism concerns.

September – June: On: 6:00 a.m. Off: At Dawn On: At Dusk Off: 11:45 p.m.
July and August: Exterior Lights Off

3.37.3. Exterior School Sign

Controlled by integral controls provided with school sign packages (no BAS controls are anticipated)

3.38. Domestic Hot Water Recirc Pump (only enable disable based on time of day schedule for secondary schools - elementary to use stand alone time/aquastat provided by others

3.39. Low Temperature Alarm Sequence of Operation

3.39.1. Space Temperature

If any space temperature falls below 14 °C (adjustable), after 30 minutes, a local “heat loss” alarm will be activated through the security system.

System Integration

When adding new zones to an existing school, integration of the new zone’s lowest space temperature is to be sent in from the new BAS system over to the existing BAS system via software or hardware point tied-in from the new BAS system to the existing BAS system. The original BAS system will have to have its software updated to accommodate the new heat loss point.

3.39.2. Hot Water Heating Supply Water Temperature

Applicable only when heating is enabled.

If the hot water heating supply water temperature is more than 15 °C (adjustable) below the setpoint or falls below 45 °C, a critical alarm will be activated through the security system. An alarm will also be generated at the BAS. The alarm will be disabled when outdoor air temperature is above heating enable setpoint.

3.40. Free Cooling Setpoint Sequence of Operation

The average outdoor air relative humidity is sent from the Vista Server to the Global Input for all schools where the Free Cooling Setpoint is calculated.

Free cool when OAT < minimum (23 °C, 29.4 °C - Φ/7.43) where Φ is the average relative humidity in %RH.

The free cooling signal is 100 % when the outdoor air temperature is more than 2 °C less than the free cooling setpoint.

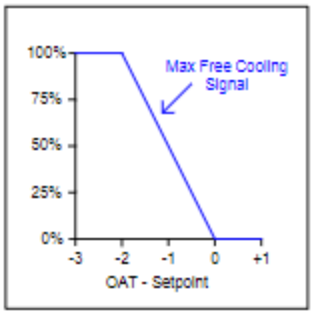
The free cooling signal decreases towards zero linearly as the outdoor air temperature increases from 2 °C less than the free cooling setpoint to 0 % at the setpoint.

This free cooling signal is used in each mixed air damper controller as the maximum the outdoor air dampers can open.

Minimum outdoor air damper position signal may exceed the free cooling signal.

The free cooling signal is still subject to the mixed damper safeties that would keep minimum position during occupied mode.

Also the free cooling signal will be at a lower priority than the CO_2 demand ventilation (where applicable) up to 40 % outside damper position.



Detail 1

3.41. Miscellaneous Monitoring

3.41.1. Sump Pump Level Alarm (not by BAS)

3.41.2. VFD Drive Fault
Provide a dry contact input to sense if VFD drive is in fault mode.
Produce an alarm at the BAS.

3.41.3. Boiler Fault
Provide a dry contact input to sense if Boiler is in fault mode.
Produce an alarm at the BAS.

3.41.4. Chiller Fault
Provide a dry contact input to sense if Chiller is in fault mode.
Produce an alarm at the BAS.

3.41.5. Rooftop Unit Fault
Provide a dry contact input to sense if the Rooftop Unit (where applicable) is in fault mode.
Produce an alarm at the BAS.

3.41.6. Fire Alarm Active
Provide a dry contact input to sense if Fire Alarm Active.
Produce an alarm at the BAS.

3.41.7. Ventilation Lockout Button Active
Provide a dry contact input to sense if the push button is active.
Indicate status on main graphic.

3.41.8. Occupancy Sensor Active
Provide a dry contact input to sense if Occupancy Sensor is Active.
Where applicable, read status of push button override on space sensor.

3.41.9. Weekly Fan Runtime
Provide a totalized point (measured in hours) of the fan status for use in trending and reports.
Reset to 0 hours each Monday at 00:00 hours.
Alarm at BAS when run time exceeds user adjustable threshold as shown on system graphic. (typically 60 hours)

3.42. Energy Conservation Measures

3.42.1. Demand Limiting Control
Energy conservation measures to strategically curtail the use of certain equipment (i.e. chillers, VFD drives) in order to not trigger excess electricity demands at peak load times.

3.42.2. Orderly Shutdown
Energy conservation measure to strategically curtail (reduce) the runtime of stages of heating and cooling by a variable amount of time before the end of occupancy.

3.42.3. Weekly fan runtime monitoring
A monitoring tool to track the amount of Fan Runtime on a weekly basis. A report quickly identifies the fans that ran an excessive amount of time.

3.42.4. Trend generation
Trends Logs are collected at the BAS server level for charting and exporting for analysis.

3.42.5. Trend Archival operations
Export logs and charts for future reference.

3.42.6. Trend Data Analysis Support
Trends Logs are collected at the BAS server level for charting and exporting for analysis.

3.42.7. Reporting Requirements
Keep consistent point naming conventions to allow for searches of logs and trends into reports across a system, site and multiple sites.

3.43. Setpoints and Schedule Standards

3.43.1. Default Occupied Room Heating Setpoint
Typically 21 °C.

3.43.2. Default Occupied Room Cooling Setpoint
Typically +3 °C above Default Occupied Room Heating Setpoint, limited to a minimum of 23.5 °C.

3.43.3. Default Standby Room Heating Setpoint
Typically 20 °C.

3.43.4. Default Standby Room Cooling Setpoint
Typically +3 °C above Default Occupied Room Heating Setpoint, limited to a minimum of 23.5 °C.

3.43.5. Default Unoccupied Room Heating Setpoint
Typically 19 °C.

3.43.6. Default Unoccupied Room Cooling Setpoint
Not used at WRDSB. (No mechanical cooling during unoccupied hours).

3.43.7. Default Gym Occupied Room Heating Setpoint
Typically 19 °C.

3.43.8. Default Occupied Schedule
Typically 7:00 a.m. to 4:00 p.m. Monday to Friday.

3.43.9. Default Standby Schedule
Typically 4:00 p.m. to 11:00 p.m.

3.43.10. Holiday Calendar Schedule
Board Holidays:
January 1st - New Year's Day
Family Day - Varies
March Break - Varies
July 1st - Canada Day
Labour Day - Varies
Thanksgiving - Varies
Winter Break - Varies
December 25 - Christmas Day
December 26 - Boxing Day

3.44. Alarm Handling

Alarms in Xenta are generated and pushed into the BAS.
Alarms in Distech can be programmed into the EC-BOS (JACE 8000) as a point extension and reported to the EC-BOS alarm console.

3.45. Outside Air Temperature

Located on the north face of the building.
Wired to a dedicated input, typically on a boiler controller (where applicable) or a master BAS controller and is shared across the BAS network to all the controllers in the building.
Used to reset setpoints and to enable/disable equipment for energy savings.

3.46. Outside Air Humidity

Located on the north face of the building.
Wired to a dedicated input, typically on a rooftop controller (where applicable) or a master BAS controller and is shared across the BAS network to all the controllers in the building.
Used to restrict free cooling if outdoor air conditions are not appropriate.

3.47. Carbon Dioxide

Located in the return air duct or room sensor.
Used to reset the minimum damper position.

3.48. Static Pressure

Located in the supply air duct referenced to a ceiling plenum (that has a constant neutral pressure) typically in VAV and VVT systems.
Used to control system pressure via the bypass damper for VVT or VFD fan speed in VAV systems.

3.49. Graphics

Systems are to be represented with line drawing graphics and not 3-dimensional graphics.
Line drawing graphics are more space efficient and load faster across networks.

3.49.1. Navigation
Central menu displaying all systems made available with hyperlinks.

3.49.2. Structure
Points folders are grouped under their physical controllers.
System folders containing the relevant points are grouped together.

3.49.3. Symbols
Two dimensional symbols and line based ductwork and piping diagrams.

3.49.4. Colours
Green text for user adjustable setpoints
Magenta text for calculated setpoints
Black text for sensors, statuses, inputs in general.
Red text for binary output commands in the Stop state.
Green text for binary output commands in the Start state.
Black text for analog control points like valves and dampers.

3.49.5. Legend
Indicate the meaning of the text colours.

3.49.6. Floor Plan
Scan from architectural drawings, simplify and format to convey the building envelope and room locations with current room names.
Zone temperatures with colour coded links to zones and systems from the graphic.

3.49.7. Systems
Two dimensional symbols and line based ductwork and piping diagrams.
Access to setpoints and schedules.

3.49.8. Setpoint
Green text for user adjustable setpoints
Magenta text for calculated setpoints

3.49.9. Levels of Access
Casual user: read only
Technical user: read/write access to setpoints and schedules, override access to points.

3.50. Security

3.50.1. Levels of Access
Casual user: read only
Technical user: read/write access to setpoints and schedules, override access to points.
External network access is not available. All network access is to be made on-site or from the Board Office.

4. Appendix:

4.1. Appendix A: Humidity-Limited Free Cooling Table

OAH		FreeClgSp		OAT		Difference		FreeClgMax	
85	%RH	17.96	°C	0	**°C**	**-2**	°C	**100**	%OA
99	%RH	16.08	°C	0	**°C**	**-2**	°C	**100**	%OA
45	%RH	23.34	°C	0	**°C**	**-2**	°C	**100**	%OA
60	%RH	21.32	°C	10	**°C**	**-2**	°C	**100**	%OA
70	%RH	19.98	°C	11	**°C**	**-2**	°C	**100**	%OA
80	%RH	18.63	°C	12	**°C**	**-2**	°C	**100**	%OA
60	%RH	21.32	**°C**	13	**°C**	**-2**	°C	**100**	%OA

OAH		FreeClgSp		OAT		Difference		FreeClgMax	
100	%RH	15.94	°C	13	°C	-2	°C	100	%OA
95	%RH	16.61	°C	14	°C	-2	°C	100	%OA
100	%RH	15.94	°C	14	°C	-1.94	°C	97.05	%OA
85	%RH	17.96	°C	15	°C	-2	°C	100	%OA
95	%RH	16.61	°C	15	°C	-1.61	°C	80.7	%OA
100	%RH	15.94	°C	15	°C	-0.94	°C	47.05	%OA
80	%RH	18.63	°C	16	°C	-2	°C	100	%OA
85	%RH	17.96	°C	16	°C	-1.96	°C	97.99	%OA
90	%RH	17.29	°C	16	°C	-1.29	°C	64.35	%OA
95	%RH	16.61	°C	16	°C	-0.61	°C	30.7	%OA
100	%RH	15.94	°C	16	°C	0	°C	0	%OA
70	%RH	19.98	°C	17	°C	-2	°C	100	%OA
80	%RH	18.63	°C	17	°C	-1.63	°C	81.64	%OA
90	%RH	17.29	°C	17	°C	-0.29	°C	14.35	%OA
70	%RH	19.98	°C	18	°C	-1.98	°C	98.94	%OA
80	%RH	18.63	°C	18	°C	-0.63	°C	31.64	%OA
90	%RH	17.29	°C	18	°C	0	°C	0	%OA
70	%RH	19.98	°C	19	°C	-0.98	°C	48.94	%OA
80	%RH	18.63	°C	19	°C	0	°C	0	%OA
90	%RH	17.29	°C	19	°C	0	°C	0	%OA
70	%RH	19.98	°C	20	°C	0	°C	0	%OA
80	%RH	18.63	°C	20	°C	0	°C	0	%OA
90	%RH	17.29	°C	20	°C	0	°C	0	%OA
70	%RH	19.98	°C	21	°C	0	°C	0	%OA
80	%RH	18.63	°C	21	°C	0	°C	0	%OA
90	%RH	17.29	°C	21	°C	0	°C	0	%OA
70	%RH	19.98	°C	22	°C	0	°C	0	%OA
80	%RH	18.63	°C	22	°C	0	°C	0	%OA
Inputs - Difference Limited to 0 and -2 °C				Outputs - Limited to 0 to 100 %OA					

OAH		FreeClgSp		OAT		Difference		FreeClgMax	
Inputs Difference= FreeClgSp-OAT (°C)		Outputs %Outside Air Damper Position (%OA)							
-2	**°C**	**100**	**%OA**						
0	**°C**	**0**	**%OA**						

4.2. Appendix B: Outside Air Temperature Limited Free Cooling Table

Outside Air Temperature (OAT)		Outside Air Temperature Limited (OAT LImited)		Final Damper Position High Limit (OatLL)	
-30	°C	-20	°C	**0**	%OA
-25	°C	-20	°C	**0**	%OA
-20	°C	-20	°C	**0**	%OA
-19	°C	-19	°C	**3.33**	%OA
-18	°C	-18	°C	**6.67**	%OA
-17	°C	-17	°C	**10**	%OA
-16	°C	-16	°C	**13.33**	%OA
-15	°C	-15	°C	**16.67**	%OA
-14	°C	-14	°C	**20**	%OA
-13	°C	-13	°C	**23.33**	%OA
-12	°C	-12	°C	**26.67**	%OA
-11	°C	-11	°C	**30**	%OA
-10	°C	-10	°C	**33.33**	%OA
-9	°C	-9	°C	**36.67**	%OA
-8	°C	-8	°C	**40**	%OA
-7	°C	-7	°C	**43.33**	%OA
-6	°C	-6	°C	**46.67**	%OA
-5	°C	-5	°C	**50**	%OA
-4	°C	-4	°C	**53.33**	%OA
-3	°C	-3	°C	**56.67**	%OA
-2	°C	-2	°C	**60**	%OA
-1	°C	-1	°C	**63.33**	%OA
0	°C	0	°C	**66.67**	%OA
1	°C	1	°C	**70**	%OA
2	°C	2	°C	**73.33**	%OA
3	°C	3	°C	**76.67**	%OA

Outside Air Temperature (OAT)		Outside Air Temperature Limited (OAT LImited)		Final Damper Position High Limit (OatLL)	
4	°C	4	°C	**80**	%OA
5	°C	5	°C	**83.33**	%OA
6	°C	6	°C	**86.67**	%OA
7	°C	7	°C	**90**	%OA
8	°C	8	°C	**93.33**	%OA
9	°C	9	°C	**96.67**	%OA
10	°C	10	°C	**100**	%OA
20	°C	10	°C	**100**	%OA
25	°C	10	°C	**100**	%OA
				Oat	**OatLL**
				-20	**0**
				10	**100**

4.3.