ALBERTA INFRASTRUCTURE

GUIDELINE

FOR

HIGH PERFORMANCE MODULAR CLASSROOM CONTROLS

2013

Capital Projects
Technical Services Branch

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1. General

1.1 INTENT

.1 The intent of this document is to provide guidance regarding the scope, installation, configuration and programming of the system that will be used to control the mechanical equipment and lighting in a high performance modular classroom. It will also cover backups and documentation for operations staff as well as a user guide for teaching staff.

.2 A major aim of the AI High performance modular classroom Program is to provide students and teachers with classroom units that have a level of indoor air quality and comfort comparable to that of any regular classroom. AI has also embraced the concept of Green design and the high performance modular classrooms are being designed and constructed with these initiatives in mind. The guideline will deal with the desired control sequences to be used to provide this comfortable environment in an energy efficient manner. These will integrate mechanical system control, occupancy sensing, equipment scheduling as well as lighting override/control.

.3 Additional operational features such as tie-ins for a school security system and dial-out mechanical alarm will also be detailed.

.4 A major component of the guideline is to provide a common interface "profile" based upon BACnet objects to facilitate interfacing various classrooms from differing vendors into a school's EMCS network in a standardized fashion.

1.2 ABBREVIATIONS

.1 BACnet: ASHRAE Standard Building Automation & Control Network Protocol
.2 CCS: Central Control Station
.3 EMCS: Energy Management Control Systems
.4 PCS Portable Control Station
.5 PCU: Programmable Control Unit
.6 PID: Proportional Integral Derivative

1.3 BASIC MECHANICAL & ELECTRICAL REQUIREMENTS

.1 The mechanical system is to include:
- .1 an exhaust fan to ensure positive entry of 212 L/s of fresh air
- .2 heating with minimum 4-1 turndown, 2-1 if heat reclaim is provided
- .3 humidifier
- .4 small sump and sump pump, c/w high level alarm
- .5 100% outside air free cooling capability

.6 mixing dampers for non-displacement systems
.7 heat reclaim and CO2 sensor

.2 System must be designed and component sizing selected such that temperature swing during any form of cycling operation under any heating, cooling or ventilation mode is less than 5 degC.

.3 Include room for DX cooling and all necessary controls and programming for this function whether or not classroom is being equipped with cooling.

.4 System must be designed such that there are no marked changes in classroom pressurization under any combination of supply fan speed, damper position or exhaust fan operating status.

.5 A contactor is required for overall control of the lighting. If daylight harvesting is being employed, then additional controls or control interfaces will be required. Ensure these are compatible with the PCU.

.6 Program start ballasts are required to preserve lamp life under frequent switching.

.7 Mechanical and electrical requirements must be coordinated with the mechanical and electrical disciplines.

2. Standard Functional Profile

2.1 GENERAL

.1 The ultimate purpose of a high performance modular classroom is to allow it to be moved from one site to another with little difficulty. Since it is expected that classrooms will be sourced from a variety of manufacturers and will be supplied with different mechanical systems, it is necessary to ensure that the controls appear the same from one classroom to another, in as much as this is possible. Without such standardization, significant unnecessary expense is added to a move.

.2 BACnet has been chosen as the interface standard mainly because all previous high performance modular classrooms have included native BACnet compliant hardware. However, a major benefit of BACnet is that it allows auto-discovery of connected hardware and exposed “objects”. Integration of a high performance modular classroom to a school’s EMCS is greatly facilitated if the exposed objects follow a common naming convention and offer identical functionality. Consistency of common features is mandatory.

.3 For the purposes of this guideline, these objects will be broken down into three types:

.1 Basic operational objects required for day to day operation/interaction with the mechanical system. These are not specific to actual equipment, but are generic in nature. These include scheduling, occupancy, setpoints, failure alarms etc.

.2 Engineering objects required to setup features or tune the generic control sequences. These include system status, setpoint offsets, control loop parameters etc.

.3 Product specific objects/options not included above.

.4 In the following profile descriptions, the ## refers to the classroom number. It is expected this portion of the name will need to be changed every time a classroom is relocated and incorporated into a new network. Italicized names refer to variables or virtual points.

2.2 BASIC OPERATIONAL OBJECTS:

Note: R=read, W=write, T=trend, O=override, C=Calibrate, A=alarm&limits
* = Objects that are required only if related options have been included

Name	Description and (units)	Interaction
RC##OAT	Outside Air Temperature AI (degC)	RTC
RC##ST	Space (classroom) Temperature AI (degC)	RTCA
RC##RH	Space Relative Humidity AI (%RH)	RTCA
RC##CO2	CO2 AI (PPM)	*RTC
RC##LL	Light Level AI (Lux)	*RT
RC##L	Lighting Contactor DO (On/Off)	RWTO
RC##OCCUPIED	Occupied Mode flag (Yes/No)	RWTO
RC##ST_USP	User Space Temp Setpoint (degC)	RWTO
RC##LL_SP	Light Level Setpoint (Lux)	*RWTO
RC##ST_24max	Max space temp over last 24 hrs (degC)	RT
RC##ST_24min	Min space temp over last 24 hrs (degC)	RT
RC##OAT_24max	Max OAT over last 24 hrs (degC)	RT
RC##OAT_24min	Min OAT over last 24 hrs (degC)	RT
RC##ST_24max	Max space temp over last 24 hrs (degC)	RT
RC##ST_24min	Min space temp over last 24 hrs (degC)	RT
RC##RH_24max	Max RH value over last 24 hrs (%RH)	RT
RC##RH_24min	Min RH value over last 24 hrs (%RH)	RT
RC##CO2_24max	Max CO2 value over last 24 hrs (PPM)	*R
RC##CO2_24min	Min CO2 value over last 24 hrs (PPM)	*R

2.3 ENGINEERING / MAINTENANCE RELATED OBJECTS:

Note: R=read, W=write, T=trend, O=override, C=Calibrate, A=alarm&limits
* = Objects that are required only if related options have been included

Name	Description and (units)	Interaction
RC##SAT	Supply Air Temperature AI (degC)	RTCA
RC##MAT	Mixed Air Temperature AI (degC)	RTCA
RC##OCCS	Occupancy Sensor DI (On/Off)	RT
RC##TC	Time Clock DI (Occupied/Unoccupied)	RT
RC##OCCMOR	Man Occup Override Button DI (On/Off)	RWO
RC##FAULT	Mech fault DI, flamefail etc (Alarm/Normal)	RTA
RC##SUMP_HI	High Sump level Alarm DI (Alarm/Normal)	RTA
RC##SF	Supply Fan continuous run DO (On/Off)	RWTO
RC##EF	Exhaust Fan DO (On/Off)	RWTO
RC##H	Humidifier control DO (On/Off)	RWTO
RC##HTG_E	Heating Enable DO (enabled/disabled)	*RWTO
RC##CLG	Cooling element (DX coil) DO (On/Off)	RWTO
RC##CLG_E	Cooling Enable DO (Enabled/Disabled)	*RWTO
RC##MALM	Mechanical Alarm DO (Alarm/Normal)	RTA
RC##MAD	Mixed Air Damper AO (%)	RWTO
RC##HTG_R	Heating Reset AO (%)	*RWTO
RC##OCCsched	Occupancy Schedule Option (Yes/No)	RWO
RC##OCCtclk	Occupancy TimeClock Option (Yes/No)	RWO
RC##OCCesave	Occupancy EnergySave Option (Yes/No)	RWO
RC##OCCco2	CO2 Control Option (Yes/No)	RWO
RC##CLG_INSTALLED	Cooling Available option (Yes/No)	RWO
RC##OCC_MORT	Occupancy Manual Override Time (min)	RWO
RC##OCC_TMR	Manual occupancy count down timer (min)	R
RC##OCC_WS	Occupied Mode Weekly Schedule	RWTO
	All schedule setup parameters	RW

RC##OCC_AS	Occupied Mode Annual Schedule	RWTO
	All schedule setup parameters	RW
RC##OCC_PROB	Occupancy Probability (%)	RWTO
RC##ST_SP	Operating Space Temp Setpoint (degC)	RWTOA
RC##ST_SPmax	Max allowed SpaceTemp setpt (degC)	RW
RC##ST_SPmin	Min allowed SpaceTemp setpt (degC)	RW
RC##ST_NSP	Night setback space temp setpoint (degC)	RWTO
RC##ST_CO	Space Temp Controller Output Value (%)	RWTO
	All control loop setup parameters	RW
RC##ST_PG	ST Loop Proportional Gain ( )	RWO
RC##ST_IG	ST Loop Integral Gain ( )	RWO
RC##RH_SP	RH Setpoint (%)	RWTO
RC##SAT_SP	SAT Setpoint (degC)	RWTO
RC##MAT_SP	MAT Setpoint (degC)	RWTO
RC##MAT_CO	Mix Air Temp Controller Output Value (%)	RWTO
	All control loop setup parameters	RW
RC##MAT_PG	MAT Loop Proportional Gain ( )	RWO
RC##MAT_IG	MAT Loop Integral Gain ( )	RWO
RC##MAD_MIN	Mixed Air Damper Min Posn. (%)	RWTO
RC##HTG	Heating element output value (%) Note: multi stage firing value would also be shown in % of fire i.e. 50%, 100%	RT
RC##HR_DFRST	Heat Reclaim in Defrost mode (Yes/No)	*RWTO
RC##HR_DFRSTdur	Defrost cycle duration (minutes)	*RWTO
RC##HR_DFRSTper	Defrost cycle period (hours)	*RWTO
RC##L_INTMR	Lighting Interupt Timer (On/Off)	RWTO
RC##CO2_SP	CO2 Setpoint (PPM)	*RWTO
RC##CO2_HIALM	CO2 High Alarm (Alarm/Normal)	*RTA
RC##CO2_FAULT	CO2 sensor fault (Alarm/Normal)	*RWTOA
RC##DTIME	Decimal 24hr Time (Hrs)	RT

3. Control Sequences

3.1 GENERAL

.1 In many ways, the older standalone portables were somewhat less problematic because these mechanical systems were very simple in nature and the typical thermostat interface was generally straight forward in nature and well understood by most people. Unfortunately, the older mechanical systems did not provide good comfort conditions, were not energy efficient and could not be counted-on to provide the required amount of outside air for proper ventilation.

.2 In response to indoor air quality concerns and energy efficiency, the current high performance modular classrooms have mechanical and control systems that are much more complex. Heating is now modulated or at least staged, mixing dampers modulate in response to space demands, mechanical cooling may be available and heat reclaim is now standard. Occupancy can be scheduled or sensed and lighting controls can be simple overrides or include daylight harvesting. Resulting control sequences are not only lengthy but more highly integrated.

.3 Programming style should be of a form that enables the control strategies to be easily followed. Clarity, simplicity and elegance are more important than program size. Extensive inclusion of comments is mandatory. Hundreds of classrooms will be constructed, a little extra time spent in preparation and documentation will have huge paybacks during warrantee and beyond.

.4 Text based programs must be modular in nature and as structured as the language will permit. Unconditional branching should be used sparingly. All jumps from the body of a module should target the end of that module. Similarly, jumps from the body of a sub-module should target the end of that sub-module.

.5 Graphic style programming must be nested/broken into easily manageable modules that can be clearly shown on letter sized sheets. Each to be well annotated with text descriptions of the function of each such graphic page. Large function blocks should have all parameters listed on accompanying pages.

.6 The control sequences need to accommodate the following scenarios:

  .1 Controls completely self contained with occupancy determined by classroom occupancy sensor only. When occupancy is sensed, lights are enabled and the mechanical system operates in daytime occupied mode. When occupancy is no longer being sensed, the outside air is slowly decreased to zero, after a time delay, lights are turned off and the mechanical system is shut down and operated in night setback mode.

  .2 Controls completely self contained with occupancy determined by internal weekly and annual schedules. Mechanical systems and lights operate during occupied hours regardless of occupancy sensor readings. During unoccupied hours, the occupancy sensor only enables lighting, the mechanical system remains in night setback mode.

  .3 Controls completely self contained, similar to 2) above, but occupancy sensor is also used in occupied mode to save extra energy by decreasing outside air intake and turning out the lights when no occupancy is sensed. This is the default mode of operation.

  .4 Controls interfaced to simple time-clock. Similar to 2) above, but external contact input is used instead of internal schedules.

.5 Controls interfaced to simple time-clock similar to 4) above, but occupancy sensor is used in occupied mode to save extra energy by decreasing outside air intake and turning out the lights when no occupancy is sensed.

.6 Controls interfaced to school EMCS. Similar to 4) or 5) above but school's EMCS can be programmed to override classroom's internal occupancy schedules, energy savings option flag as well as the various setpoints. If necessary, it would also be possible to perform these as well as other functions manually from offsite.

.7 Manual activation of override timer forces mechanical system into normal occupied operating mode for a predetermined interval, irrespective of any of the above settings.

.7 The mechanical system may use a modulating or multistage gas valve or even some other form of heating. The system will also use some form of heat recovery. This may be in the form of a heat wheel, heat pipe or air-to-air heat exchanger with built in exhaust fan. The programming must be written such that these differences are hidden from the basic operational profile. As an example, heating is to be a value between 0-100%. This can directly represent a modulating gas valve or electric heating coil. Multistage firing rates would show as stepped values (i.e. 4 stages would be 25%, 50%, 75%, 100%). Special, vender specific, setup parameters could be made available via additional product specific objects/options.

.8 Although mechanical cooling may not be installed when a high performance modular classroom is constructed, many boards add cooling soon after delivery. Direct DX cooling control point **RC##CLG** and/or cooling system enable point **RC##CLG_E** must be provided as well as all related control strategies. Parameter ***RC##CLG_INSTALLED*** units "Yes/No" is used to enable/disable control of cooling.

.9 It is not necessary to create programming exactly as shown in the following articles. The sample programming uses various techniques and mixed mode mathematics that are not available to all systems. Such details should be treated as a guideline as to how the sequences are to operate. It is **not** the intent of this guideline to limit the vendor to specific methods of programming or diminish their responsibility for producing a reliable product. More efficient strategies and techniques are welcome as long as the functionality described in this guideline is incorporated and comfort and energy efficiency are not compromised.

.10 Controls programming MUST take into account the possibility of improper user input. Humans are fallible and make entry and judgment errors. Setpoints and other input should be checked for reasonableness etc. There should be no way the unit could be placed into an operating mode that would lead to premature equipment failure, no matter how long the unit operates under these conditions. Error messages should help guide the user to the correct action without implying a negative context. For example, it would be better to say "Occupied setpoint must be within comfort range 21 to 24 degC" rather than simply "Illegal entry" without any indication of what was entered or what is the allowed range.

3.2 BUILDING OPERATING MODES

.1 Three fundamental modes of operation are defined:

.1 Occupied: Normal operation, space at normal occupied setpoint, main fan continuous operation, exhaust fan and mixing dampers set to provide required outside air with free cooling capability and heating/cooling are enabled. Pressing the thermostat's occupancy button will put the space into occupied mode operation for the number of minutes contained in variable ***RC##OCC_MORT***. The transition into occupied mode is also to incorporate warm-up and purge functions as follows:

.1 Warm-up: This function is active whenever the space temperature is noticeably below setpoint as would occur during startup after a night setback period or with an equipment failure. During this mode, the amount of fresh air is smoothly decreased to allow for greater heating capacity and quicker recovery as follows:

Temp. below setpt	Max allowed mixing damper position
3 degC	0 % (fully closed)
0.5 degC	100% or as desired by normal programming

Mixing damper position	Exhaust Fan
Less than ½ of ***RC##MAD_MIN***	OFF
Greater or equal to ***RC##MAD_MIN***	ON

.2 Purge: This function simply disables mechanical DX cooling during the first 20 minutes of occupancy.

.2 Occupied with Energy Savings Active: This is similar to the regular occupied mode but includes features to conserve energy if no actual occupancy is being sensed. As the probability of occupancy drops below 20%, the lights are pulsed off for one second, mixing dampers slowly close over 5 minutes and the exhaust fan goes off once the dampers have closed to less than ½ of their minimum ventilation position. The one second lighting interruption notifies any occupants that there has been insufficient activity to indicate occupancy and all that is required is a single activation of the occupancy sensor to reinstate normal occupied mode control.

.3 Unoccupied: Space at night setback temperature, supply fan off except as required to intermittently heat the space, exhaust fan off and dampers fully closed to outside air. This mode is entered directly if an external time-clock or network override indicates that occupancy has ended. However, if occupancy is being determined using the sensors, then the stepped response used with the energy savings option precedes final system shutdown.

3.3 DEFINITIONS, SETUP PARAMETRS AND SYSTEM VARIABLES

.1 In the following control sequence descriptions, **PHYSICAL POINTS** are shown in **bold and capitalized** and ***VIRTUAL POINT***S are shown in ***bold and capitalized italics***.

.2 All parameters listed below must be able to be setup via an attached portable computer or network connection to a central control station or, directly at the keypad of the smart thermostat keypad.
NOTE: Keypad access to these settings must be protected with a pass code or similar means.

.3 Parameter ***RC##CLG_INSTALLED:*** Cooling installed, units “Yes/No”, default value “No”. Set this parameter to “Yes” if DX Cooling has been installed and is available.

.4 Parameter ***RC##MAD_MIN***: Minimum mixed air damper position, units “%”, default value as required to ensure about 212 L/s of outside air will be provided while the exhaust fan is running (i.e. typically somewhere between 30% and 40%).

.5 Parameter ***RC##OCCschd***: Internal schedule option, units “Yes/No”, default value “Yes”. Occupancy is determined via the internal weekly schedule ***RC##OCC_WS*** and annual schedule ***RC##OCC_AS***. If set to “No” then occupancy is assumed to be determined via the occupancy sensors. Initially set up weekly scheduled occupied hours between 7:30AM and 6:00PM, Monday through Friday. Set up annual holiday schedule for the major holidays and summer vacation from mid July through to mid August. School operator/custodian will need to make final adjustments on receipt of classroom.

NOTE: If connected to school's EMCS set the schedule option to yes and download schedules from EMCS. As an alternative, set this option to yes and create a program in the EMCS to override the status of the internal weekly and annual schedule based upon the status of he EMCS's schedules.

.6 Parameter ***RC##OCCtclk***: Hardwired time clock option, units "Yes/No", default value "No". Set parameter to "Yes" to indicate that occupancy is to be determined via the external time clock input **RC##TC**. This takes precedence over the internal weekly and annual schedules. Ideally, setting ***RC##OCCtclk*** to "Yes" would automatically reset ***RC##OCCschd*** to "No". As an alternative, it should not be possible to set ***RC##OCCtclk*** to "Yes" if ***RC##OCCschd*** is already "Yes".

.7 Parameter ***RC##OCCesave***: Energy savings option, units "Yes/No", default value "Yes". When enabled, the occupancy sensor is used to save extra energy when no occupancy is sensed during occupied conditions by turning out the lights as well as decreasing outside air intake during cold or extremely hot weather.
NOTE: This option makes no difference in manual occupancy override mode. It is assumed someone wants everything up an running, no matter what the actual occupancy.

.8 Parameter ***RC##OCCco2***: CO2 control option, units "Yes/No", default value "No". If available, the CO2 sensor is used to save extra energy by decreasing outside air quantities requirements during occupied conditions during cold or extremely hot weather.

.9 Variable ***RC##OCC_MORT:*** Occupancy Manual Override Time, units "Minutes", default value 60, entry limited to values between 30 and 240. This is the duration that the system will be put into occupied mode whenever the intelligent thermostat's occupancy manual override button **RC##OCCMOR** is momentarily depressed.

.10 Variable ***RC##OCC_TMR:*** Manual Occupancy ***C***ount Down Timer, units "Minutes", default value 0. This timer indicates the number of minutes remaining in occupied mode since the momentary closing of the intelligent thermostat's occupancy manual override button. The timer automatically counts down to zero and is set to the manual override time value ***RC##OCC_MORT*** whenever button **RC##OCCMOR** is depressed.

.11 Variable ***RC##OCC_PROB:*** Occupancy Probability, units of %, default value 0. This is a value that indicates the likelihood that the classroom is occupied. In the following sequence, the occupancy sensor must produce 3 captures within a short time to provide 99% probability and since the value is always being decreased, one activation every 6.6 minutes is required to keep probability above zero. This so called probability of occupancy goes from 100 to zero if nothing has been sensed in 20 minutes. As an added feature, the probability value is limited to 33 when schedules are enabled but indicating unoccupied OR a hardwired time clock is being used but is also indicating an unoccupied period. This allows for a much faster timeout should someone just pop in for a few moments to pick something up, or whatever.

During manual occupancy override, probability is not valid because all systems are forced ON. Just set value to 33% while in manual mode so probability is already limited when counter times out. Should there still be significant occupancy in the space, the probability will climb and the systems will remain in occupied mode as desired.

Every 3 seconds do all of the following:

If ***RC##*****OCCS** is "ON"
Then increase the value of ***RC##OCC_PROB*** by 33
Else decrease the value of ***RC##OCC_PROB*** by 0.25

Limit ***RC##OCC_PROB*** to values between 0 and 100%

If ***RC##OCCtclk*** is "Yes" AND input **RC##TC** shows **un**occupied
OR ***RC##OCCschd*** is "Yes" AND schedules are showing an **un**occupied state
Then limit ***RC##OCC_PROB*** to values between 0 and 33%

If ***RC##OCC_TMR*** > 0 (i.e. occupancy manual override is **active**)
Then set ***RC##OCC_PROB*** to 33%

.12 Parameter ***RC##ST_SPmax***: Maximum allowed Space Temp SetPoint, units "DegC", default value of 25.0, entry limited to values between 23 and 32.

.13 Parameter ***RC##ST_SPmin***: Minimum allowed Space Temp SetPoint, units "DegC", default value of 21.0, entry limited to values between 17 and 22.

.14 Variable ***RC##ST_USP***: Space Temp User SetPoint, units "DegC", default value of 22.5 DegC. This is the value of space temperature setpoint entered or adjusted by the user via the intelligent stat keypad.

.15 Controller ***RC##ST_CO***: Space temperature control loop, output units "%"
Output Range: 0-100%, but limited to 0-75% if ***RC##CLG_INSTALLED*** is "No"
Bias: Set at 45%

Controlled variable: Space temperature **RC##ST**
Setpoint: ***RC##ST_SP***
Parameter ***RC##ST_PG***: Proportional gain, default value equivalent to 25%/degC error
Parameter ***RC##ST_IG***: Integral gain, default value equivalent to 5%/degC error/hour
Miscellaneous: integral windup to be limited

.16 Controller ***RC##MAT_CO***: Mixed air temp. control loop, output units "%"
Output Range: 0-100% (0% is for dampers at full return air)
Bias: Set at 0%
Controlled variable: Space temperature **RC##MAT**
Setpoint: ***RC##MAT_SP***
Parameter ***RC##MAT_PG***: Proportional gain, default value equiv to 25%/degC error
Parameter ***RC##MAT_IG***: Integral gain, default value equivalent to 5%/degC error/hour
Miscellaneous: integral windup to be limited

.17 Parameter ***RC##HR_DFRSTdur***: Heat reclaim defrost cycle duration, units "Minutes", default value of 10 minutes.

.18 Parameter ***RC##HR_DFRSTper***: Heat Reclaim defrost cycle period, units "Hours", default value of 8 hours.

.19 Variable ***RC##HR_DFRST***: Heat reclaim in defrost mode, units "Yes/No", default value of "No".

.20 Interrupt timer ***RC##L_INTMR***: Lighting Interrupt Timer, units "On/Off", default value is Off. This timer is to turn "On" for one second every time probability ***RC##OCC_PROB*** drops below 20%. It resets after the one second activation and waits until the probability value once again goes above 20% then activates again whenever the probability value passes down through 20%.

.21 Variable ***RC##DTIME***: Decimal Time, units "Hours". This is the value of PCU time in decimal hours in 24 hour format. It can be used to check PCU clock synchronization, communications issues etc.

3.4 BASIC DATA GATHERING

.1 Create routines that provide the following maximum and minimum values over a sliding window period of the last 24 hours (hourly data is sufficient):

- .1 ***RC##OAT_24max***: Maximum outside air temperature
- .2 ***RC##OAT_24min***: Minimum outside air temperature
- .3 ***RC##ST_24max***: Maximum classroom space temperature
- .4 ***RC##ST_24min***: Minimum classroom space temperature
- .5 ***RC##RH_24max***: Maximum classroom relative humidity

.6 ***RC##RH_24min***: Minimum classroom relative humidity
.7 ***RC##CO2_24max***: Maximum classroom CO2 level
.8 ***RC##CO2_24min***: Minimum classroom CO2 level

3.5 DETERMINATION OF OCCUPANCY

.1 Occupancy sensors are to be dual technology (IR/UV, IR/Ultrasonic, etc). Select devices specifically designed for this application. The output contact should turn ON when **either** one of the sensor technologies is activated, but should turn OFF only when **both** technologies are indicating off (not just one of the two).

.2 Determination of occupancy is simple when time schedules or a time clock are available. However, in self contained mode or whenever the energy savings option is active, occupancy can only be determined via motion sensors mounted near the windows and sensing into the room.

.3 In practice it has been difficult to find a balance between responsiveness and nuisance activations. One wishes to avoid going into fully occupied mode should someone just look into the room, but it should not require there to be 10 people moving about the room either. The first indication of occupancy must enable the lights, but more activations should be required to bring on the mechanical systems.

.4 The strategy should cover the possibility of a couple of students working quietly and also provide a somewhat faster response for a larger active group. The programming must even handle the situation where a group has been working very quietly, sensed occupancy is about to expire and the lights have just been pulsed off to indicate they will be going fully off in the next 5 minutes. Any activity within the remaining time should markedly delay the onset of unoccupied mode.

.5 It also seems reasonable to limit automatic activation to hours between 6:00AM and 10:00PM. The manual override button can be used outside these hours.

.6 Since there are multiple occupancy inputs, response must be based upon their priority. Occupancy manual override has highest priority and the time clock has precedence over the schedules, sensed occupancy has the lowest priority.

.7 ***RC##OCC_PROB*** already provides much of the required functionality for sensing occupancy. It ramps up far too quickly, but can still be used with a suitable delay mechanism. The complete sequence can be summarized as follows:

If ***RC##OCC_TMR*** > 0 {i.e. occupancy manual override is active}
OR (***RC##OCCtclk*** is “Yes”, AND input **RC##TC** shows occupied)
OR (***RC##OCCtclk*** is “No”, AND ***RC##OCCschd*** is “Yes”,
AND schedules are showing an occupied state)
OR (***RC##OCCtclk*** is “No”, AND ***RC##OCCschd*** is “No”,

AND ***RC##OCC_PROB*** has been continuously above 33 for 10 minutes
AND the time is between 6:00AM and 9:00PM)
Then set ***RC##OCCUPIED*** to "Yes"
Else If ***RC##OCC_TMR*** = 0 {i.e. occupancy manual override is not active}
OR (***RC##OCCtclk*** is "Yes", AND input **RC##TC** shows unoccupied)
OR (***RC##OCCtclk*** is "No", AND ***RC##OCCschd*** is "Yes",
AND schedules are showing an unoccupied state)
OR (***RC##OCCtclk*** is "No", AND ***RC##OCCschd*** is "No",
AND (***RC##OCC_PROB*** < 1,
OR the time is NOT between 6:00AM and 9:00PM))
Then set ***RC##OCCUPIED*** to "No"

i.e. The classroom goes into occupied mode if the manual override timer is active, OR the time clock option is enabled and the time clock contact is made, OR the time clock option is not enabled but the internal schedules are active and showing an occupied state, OR occupancy is being determined solely via the occupancy sensors and these have been indicating at least some occupancy over 10 minutes and the time of day is reasonable. Otherwise, the classroom goes into unoccupied mode if the manual override timer is not active, OR the time clock option is enabled but the time clock contact is open, OR the time clock option is not enabled but the internal schedules are active and showing an unoccupied state, OR occupancy is being determined solely via the occupancy sensors and these have not seen anything for many minutes, or the time is outside serviced hours.

3.6 PACKAGED HVAC UNIT CONTROL - DETAILS

.1 Calculate the space temperature setpoint value ***RC##ST_SP*** as follows:

.1 In occupied mode when ***RC##OCCUPIED*** is "Yes" let the operating setpoint ***RC##ST_SP*** be the user set value ***RC##ST_USP*** which is limited to a range between ***RC##ST_SPmin*** and ***RC##ST_SPmax***.

.2 In unoccupied mode, when ***RC##OCCUPIED*** is "No" let the operating setpoint equal the night setpoint ***RC##ST_NSP*** but limited to values between 15 and 20 degC. ***RC##ST_NSP*** is to have a default value of 17 degC. ***RC##ST_NSP*** must not be allowed to be higher than ***RC##ST_USP***.

.2 Supply fan **RC##SF**, is to run continuously in occupied mode when ***RC##OCCUPIED*** is "Yes". In unoccupied mode the fan is only to run as necessary to maintain space at the setback setpoint. No more than 6 cycles per hour are to be allowed. i.e. minimum off time is to be about 10 minutes.

.3 Exhaust fan **RC##EF** is to run while ***RC##OCCUPIED*** is "Yes", AND supply fan **RC##SF** is running, AND mixing dampers **RC##MAD** are greater or equal to minimum position ***RC##MAD_MIN***.

.4 Exhaust fan **RC##EF** is to be OFF while ***RC##OCCUPIED*** is "No", OR supply fan **RC##SF** is OFF, OR mixing dampers **RC##MAD** are less than ½ of minimum position ***RC##MAD_MIN***. Minimum off time is to be 10 minutes.

.5 Use controller ***RC##ST_CO*** to sequence heating, mixing dampers and cooling stages as follows:

```
                  RC##ST_CO controller output
|-----------------------|------------------------|----------------|
0%                     45%                      75%             100%
      RC##HTG               RC##MAD          RC##CLG
```

NOTE: If cooling is not available (i.e. ***RC##CLG_INSTALLED*** is "No") then limit control loop output to values between 0% and 75%.
NOTE: Controller response must be tuned so as to ensure slow smooth operation. The output must not cause the cooling (DX) or heating (gas) valves to cycle more than about 6 times per hour.

.6 Separate control over mixed air temperature is often desired. This can be incorporated into the above scheme by resetting mixed air temperature setpoint ***RC##MAT_SP*** with respect to supply air temperature controller position as follows:

RC##ST_CO	***RC##MAT_SP***
75% or greater	13 degC
45% or less	23 degC

.7 Allow cooling only while **RC##SF** is ON, AND occupied mode **RC##*OCCUPIED*** is “Yes”, AND outside air temperature **RC##OAT** is greater than 18 degC. Disable DX cooling when **RC##SF** goes OFF, OR **RC##*OCCUP*** is “No”, OR **RC##OAT** drops below 15 degC. Also disallow cooling during the warm-up/purge phase that is the first 20 minutes of occupancy.

.8 When enabled for operation, control cooling as follows:

RC##ST_CO	**RC##CLG**
95% or greater	ON
75% or less	OFF

NOTE: Do not allow more than 6 cycles per hour.

.9 Mixing dampers **RC##MAD** modulate over controller ***RC##ST_CO*** output range of 45% (dampers full return air) up to 75% (dampers full to outside air). OR, if separate mixed air temperature control is being used, then modulate mixing dampers **RC##MAD** over controller ***RC##MAT_CO*** output range of 0% (dampers full return air) up to 100% (dampers full to outside air)

.10 Smoothly limit damper position during warm-up based upon the difference between classroom space temperature and setpoint as follows:

Space Temp. below Setpoint	Max allowed mixing damper position
3 degC	0 % (fully closed)
0.5 degC	100% (fully open)

.11 To ensure smooth start-up or restart during colder weather, slow the speed of damper opening such that they cannot go from fully closed to fully open in less than 10 minutes. However, allow them to close quickly if required.

.12 Include an economizer function such that mixing dampers **RC##MAD** close to minimum position ***RC##MAD_MIN*** when the outside air temperature **RC##OAT** is 2 degC above space temperature **RC##ST**. The dampers are to revert to normal operation when **RC##OAT** is 1 degC below **RC##ST**.

.13 If the energy savings option ***RC##OCCesave*** is “Yes”, AND outside air temperature is below 0 degC, then linearly limit damper opening from 100% down to 0% as ***RC##OCC_PROB*** goes from 20% down to 0%.
Note: No need to override in extremely warm weather, this is handled by the normal economizer function.

.14 Mixing dampers **RC##MAD** shall go fully closed when supply fan **RC##SF** is OFF, OR **RC##*OCCUPIED*** is “No”.

.15 In order to provide for a consistent interface profile for a variety of mechanical systems, a modulating heating element has been assumed such that 0% indicates no heat and 100% is for full heat. If a fully modulating heating element has been provided, then **RC##HTG** would be an actual analogue output point, for all other heating methodologies, control the actual hardware outputs based upon the value contained in a virtual point ***RC##HTG.*** Many scenarios also require enable/disable control over the heating device via **RC##HTG_E**. Some examples of likely possibilities follow:

.1 For a PCU controlled fully modulating device such as pulse width modulated electric heating:

RC##ST_CO	**RC##HTG**
0%	100% (full heat)
45%	0% (no heat)
RC##ST_CO	**RC##HTG_E**
50% or more	heating device disabled
40% or less	heating device enabled

.2 For a PCU controlled modulating gas valve with a 4-1 turn down ratio:

RC##ST_CO	**RC##HTG**
0%	100% (full fire)
35%	0% (minimum fire i.e. 25% output)
RC##ST_CO	**RC##HTG_E**
40% or more	heating disabled
30% or less	heating enabled

.3 For four stages of heating, a separate digital output is required for each stage. ***RC##HTG*** becomes a virtual point related to the stages as follows:

RC##ST_CO	***RC##HTG***	Heating Stage
0 – 11%	75 – 100%	Stage 4, ON @ 98, OFF @ 77
11 – 22%	50 – 75%	Stage 3, ON @ 73, OFF @ 52
22 – 33%	25 – 50%	Stage 2, ON @ 48, OFF @ 27
33 – 44%	0 – 25%	Stage 1, ON @ 23, OFF @ 2

.4 For two stages of heating, a separate digital output is required for each stage. ***RC##HTG*** becomes a virtual point related to the stages as follows:

RC##ST_CO	***RC##HTG***	Heating Stage
0 – 20%	50 – 100%	High fire, ON @ 90, OFF @ 60
20 – 40%	0 – 50%	Low fire, ON @ 40, OFF @ 10

.5 Some heating devices cannot be controlled directly by the PCU. These generally have self contained controls that maintain the supply air temperature at some setpoint value ***RC##SAT_SP***. The PCU can be interfaced to these types of controllers with enable **RC##HTG_E** and reset **RC##HTG_R**. ***RC##HTG*** again becomes a virtual point and is used to reset the supply air temperature setpoint. The values shown in the tables are included as an examples only. Actual numbers should reflect the needs of the supplied mechanical equipment.

For a heating device with a high turn down ratio:

RC##ST_CO	***RC##HTG***	**RC##HTG_R**
0%	100% (full heat)	As required for SAT setpoint of 55 degC
45%	0% (no heat)	As required for SAT setpoint of 22 degC

RC##ST_CO	**RC##HTG_E**
50% or more	heating disabled
35% or less	heating enabled

For a heating device with a 4 -1 turn down ratio:

RC##ST_CO	***RC##HTG***	**RC##HTG_R**
0%	100% (full heat)	As required for SAT setpoint of 55 degC
35%	0% (minimum heat)	As required for SAT setpoint of 30 degC

RC##ST_CO	**RC##HTG_E**
45% or more	heating disabled
30% or less	heating enabled

.16 Ensure heating equipment does not cycle excessively. Typically do not allow more than about 6 on/off cycles per hour.

.17 An electric coil may be controlled with a solid state relay that is pulse width modulated under software control.

.18 Space relative humidity setpoint ***RC##RH_SP*** is calculated as a reset function with respect to outside air temperature as follows:

RC##RH_SP	**RC##OAT**
15%	-35 degC or lower
30%	0 degC or higher

.19 Enable humidification device **RC##H** if the space relative humidity **RC##RH** is at least 5%RH below setpoint ***RC##RH_SP***, AND supply fan **RC##SF** is “On”, AND occupied mode ***RC##OCCUPIED*** is “Yes”. Turn off humidification if there is a sump alarm via **RC##SUMP_HI** is “Alarm”, OR **RC##RH** is above setpoint, OR, supply fan **RC##SF** is “Off”, OR occupied mode ***RC##OCCUPIED*** is “No”.

.20 For systems with heat reclaim:

.1 Provide software and additional sensors and controls as necessary to ensure reliable operation of the heat reclaim device under all outside conditions with minimum downtime for defrosting etc.

.2 As a minimum, provide defrost control based upon outside air temperature as follows:

.1 Reset ***RC##HR_DFRSTper*** with respect to outside air temperature:

OAT (DegC)	***RC##HR_DFRSTPer*** (hours)
-30 of less	4 hours
-10 or more	12 hours

.2 Set ***RC##HR_DFRST*** to “Yes” for a duration of ***RC##HR_DFRSTdur*** minutes every ***RC##HR_DFRSTper*** hours from start of occupied mode.

.3 Do not defrost when outside air temperature is above freezing or system is in unoccupied mode.

.3 Generally, heat reclaim would be used during occupied mode when outside air is being introduced into the classroom. However, it is to be disabled whenever this function would decrease overall energy efficiency or comfort. For example, if its warm outside but room temperature is warmer still, then running the reclaim will just warm the incoming air and reduce its ability to cool the space.

3.7 LIGHTING CONTROL

.1 For safety and security reasons, lighting must be able to be turned on as soon as there is any indication of occupancy. Therefore, enable power to lighting contactor **RC##L** as soon as occupancy sensor has had a capture (i.e. whenever ***RC##OCC_PROB*** > 30%).

.2 In general, lights are to be operational whenever the space is in occupied mode. However, when the energy savings option is active, the lights are to be turned off when the there is no sensed occupancy even if the class is in occupied mode. To ensure there are no surprises, the lights are pulsed off for 1 second about 5 minutes before they would be turned off (i.e. as ***RC##OCC_PROB*** drops below 20%). This allows time for any occupants to reinstate normal occupied mode control with a simple wave of the hand etc.

.3 The logic can be summarized as follows:

If ***RC##OCC_TMR*** > 0 {i.e. occupancy manual override is active}
OR ***RC##OCC_PROB*** > 30% {occupancy sensor has had 1 capture}
OR (***RC##OCCUPIED*** is “Yes”, AND ***RC##OCCesave*** is “No”)
OR (***RC##OCCUPIED*** is “Yes”, AND ***RC##OCCesave*** is “Yes”,
AND ***RC##L_INTMR*** is OFF) {i.e. not trying to pulse lights off for 1 sec}
Then enable **RC##L** {i.e. allow lights to be turned on}
Else disenable **RC##L** {turn lights off}

NOTE: This routine must be scanned very rapidly to ensure lights can be pulsed off properly, or some other equivalent logic must be created to achieve the same result.

.4 If daylight harvesting is to be used, then modulate appropriate classroom lights to maintain light level **RC##LL** at a setpoint ***RC##LL_SP*** adjustable from the intelligent thermostat’s keypad. Control should be reasonably rapid but time-averaged so as not to be annoying during fluctuations in daylight caused by cumulous clouds or the like.

3.8 EMERGENCY CONTROL

.1 On detection of failure of intelligent thermostat:

.1 Supply fan shall go into continuous operation.
.2 Exhaust fan shall remain off (occupied or unoccupied mode)
.3 Mixing dampers shall remain fully closed (occupied or unoccupied mode)
.4 Space temperature to be controlled using the mixed air temperature sensor.
.5 Lighting control is to remain unaltered.

3.9 CO2 MONITORING AND CONTROL

.1 Each classroom is to be equipped with a carbon dioxide sensor **RC##CO2** that provides the concentration of CO2 in parts per million (PPM).

.2 Inexpensive CO2 sensors may drift over time. Select stable electrochemical devices that are guaranteed accurate for at least 3 years or ensure devices have some form of auto zero self calibration function. Even then, the devices should be checked annually until some confidence in their reliability is attained. Sensors must be able to be checked and calibrated by operations staff. Devices that need to be sent out for calibration are not recommended. If special software and/or cables are required for calibration, provide supplier's data in the O&M Manual along with retail costs.

.3 Provide a sequence of operation that checks the minimum value of the sensor over a 24 hr period. The sliding window minimum value of CO2 level from the basic data gathering routines can be used for this check. If the lowest value over the last day has not been near the atmospheric average, then there is likely a problem with the sensor so alarm the situation: i.e.

At 10:00 AM:
IF ***RC##CO2_24min*** is NOT between 250 and 500
THEN set ***RC##CO2_FAULT*** to "alarm" and display this condition on the stat

Once the fault has been corrected a manual reset of ***RC##CO2_FAULT*** must also restore ***RC##CO2_24min*** to 499 so as to allow further collection of data starting at a "normal" value.

.4 As a minimum CO2 must be monitored. However, with the level of controls necessary to produce the sequences of operation in this guideline, it would also be possible for the system to control the amount of fresh air introduced into the space. Since the mechanical system is designed to bring in the amount of fresh air required for full occupancy, energy savings are possible if the number of students is less than maximum.

NOTE: Simple breaks in occupancy are already handled by the energy saving option, i.e. dampers closed and exhaust fan off when no occupancy is sensed.

.5 If control over fresh quantities is being implemented or considered:

.1 For reliability reasons, it is not recommended that any CO2 control routine increase fresh air quantities above that provided for in the standard mechanical design. These are already significant and provide for a fully occupied classroom.

.2 If there is a problem with the sensor (i.e. when ***RC##CO2_FAULT*** is in alarm) disable CO2 control over fresh air quantities and revert to normal fresh air rates. Only revert to CO2 controlled operation when the alarm has been manually restored (i.e. the operations staff have corrected the problem)

.3 Setpoint ***RC##CO2_SP*** should be conservative. A default value of 800 PPM would be reasonable and the classroom should not be allowed to exceed 1000 PPM for any significant duration. Only allow setpoints between 750 and 900. It should be remembered that the whole purpose of these advanced high performance modular classrooms is to improve environmental conditions for the students.

.4 Since the mechanical system requires some form of heat reclaim, the amount of energy to be saved by CO2 control is diminished. Decreasing the flow rate of fresh air must be balanced by decreases in exhaust rates. On/off control of the exhaust fan is not an adequate means of control in an occupied classroom, some form of speed control or modulation is required. This complicates an already complicated mechanical system.

.5 Decreased air flow through the heat reclaim will make certain types significantly more efficient, which is beneficial in one respect but it also makes the unit much more prone to frost and ice buildup. Increased defrosting may be required. Water pooling in the unit in never a good thing.

3.10 ALARM PROGRAMS

.1 Enable mechanical alarm output **RC##MALM** when any of the following critical alarms is detected:

- .1 Low space temperature via **RC##ST** < 12 degC.
- .2 Mechanical system failure via **RC##FAULT**.
- .3 High sump alarm via **RC##SUMP_HI**
- .3 Intelligent-thermostat (user interface) failure.

.2 It is understood that a simple furnace does not have an available fault output contact for **RC##FAULT** but it is assumed that other information will be used in conjunction with low classroom space temperature to provide similar functionality. For example: If classroom temperature is below setpoint, and the furnace is supposed to be firing in low or high fire, and the supply air temperature has been below 30 degC for the last 15 minutes, then it can safely be assumed there is a furnace failure and a virtual ***RC##FAULT*** value can be set to TRUE.

.3 Display an alarm on the intelligent-thermostat when any of the following non-critical alarms is detected:

.1 ***RC##CO2_HIALM***, high CO2 level via **RC##CO2** > 1000 PPM for 30 min (if CO2 device is available)
.2 ***RC##CO2_FAULT***, CO2 sensor fault (if CO2 device is available)

4. Documentation

4.1 CONTROLS O&M MANUAL, O&M DISK AND SYSTEM BACKUP

.1 Provide one complete copy of a Controls Operation and Maintenance Manual as follows:

.1 Divisions :
.1 Controls: Hardware (Configuration/Installation)
.2 Controls: Software (Database/Programming)
.3 Controls: Maintenance
.4 O&M Disk (full manual in electronic format)
.5 Backup Disk

.2 A D-ring binder with two plastic sheet lifters and clear outside overlay pockets is acceptable.

.3 Binder cover and spine shall display the project title, classroom model, date of manufacture, serial number and manufacturer's name. The cover sheet should also have "DO NOT REMOVE FROM CLASS MECHANICAL ROOM" in bold red near the bottom. Other information and logos may be added to the cover as desired.

.2 Controls - Hardware (Configuration/Installation):

.1 Organize the information into sections, with index and divider tabs, as follows:
.1 Configuration (include explanations of architecture)
.3 System Schematics
.4 PCU

.2 Configuration: Provide a basic configuration diagram showing PCU and related devices. Provide an explanation of system architecture. Describe each hardware component and the networks that manage system communications.

.4 System Schematics: Provide schematics of the mechanical system indicating point locations, mnemonics and hardware address. Include any wiring details and equipment schematics showing where and how equipment is interfaced to PCU. Drawings must be clear and of adequate size for easy reading. If necessary, fold larger sheets into binder.

.5 PCU: Provide a copy of the PCU panel directory showing point mnemonics, termination addresses and wiring numbers. Also include the panel directory of any associated equipment/interface cabinet.

.3 Controls - Software (Database/Programming):

.1 Organize the information into sections, with index and divider tabs, as follows:
- .1 Point/object Tables
- .2 Graphics
- .3 Descriptions and Procedures
- .4 PCU

.2 Point/object Tables: Provide two lists that, when combined, contain all the physical and virtual points/objects as well as a suitable description as to their function and their database address. The first table is to contain only the standard profile objects, the second to contain all remaining objects.

.3 Graphics: Provide a hardcopy of recommended graphic display screens.

.4 Descriptions and Procedures: Provide a description of overall control philosophy. Describe all hardware interlocks with other equipment that may affect or override action of software control modules. Provide procedures for operating staff to interface with software control modules, to override system or component operation, to adjust system control setpoints, etc. Name virtual points provided in software for this purpose and recommend adjustment increments and limits where applicable

.5 PCU: Provide the following information separated with coloured sheets:
- .1 List of physical and virtual point mnemonics, with a detailed description of the meaning of each mnemonic.
- .2 For each User Control Language Program module in the PCU provide:
  - .1 a description of purpose and logic of module.
  - .2 a hardcopy listing of the program module.
- .3 Complete hardcopy listing of the database. Include each hardware point, virtual point, schedule, report, trend, controller etc.

.4 Controls Maintenance:

.1 Provide a description of maintenance procedures for all equipment and systems. Include a schedule for recommended planned and preventative maintenance work and intervals. Include a list of resources to call upon for maintenance and servicing of equipment. Provide the supplier’s name, address and phone number as well as the service contact.

.5 O&M Disk (full manual in electronic form):

.1 In addition to the hardcopy manuals, provide the Operation and Maintenance Manuals in electronic form as follows:

.1 O&M data shall be organized exactly as specified for the hardcopy manuals.

.2 Data shall be compiled into Adobe portable document format and assembled into as few files as practical. (NOTE: It would be preferable if there were no more than one file per division.)

.3 Include table of contents links that allow direct access to data as per the divider tabs required in the hardcopy manual.

.2 Provide an O&M Disk, in the form of a CD-R. Insert in suitable pouch in hardcopy manual.

.6 Backups: Provide two (2) complete system backups, each must contain everything necessary to restore the system to full operation should a catastrophic failure occur. Also include a jpg, gif or dxf version of the graphic display screen that can be used by a host system in the future. One package is to be included in the Operation & Maintenance Manual that will remain in the "Manuals" cabinet in the portable classroom's mechanical space. The remaining package is also to be in the cabinet but in a separate enveloped marked "SYSTEM BACKUP".

4.2 TEACHER'S GUIDE

.1 This guide/pamphlet is to provide casual users such as teachers, custodial staff or even students, with basic operating information for the user interface (smart thermostat). It must be written in a clear straight forward manner and be free of acronyms and technical language. Pictures and graphics should be used as much as possible to illustrate operations and concepts. Include information as follows:

.1 Display Screen: Show screen layout and displayed information such as room and outside air temperature, relative humidity, occupancy and operating mode if applicable. Graphics and/or annotated pictures of actual displays should be included.

.2 Keypad: Show keypad layout, label each key and provide basic information as to operation of each key.

.3 Operation: Pictorially and textually guide the casual user through the use of the basic thermostat menu options such as setting temperature setpoint, occupancy override and setting light level (if available).

.4 Occupancy Sensing: Provide a clear description of how the occupancy sensor works, how it is used to determine occupancy and what are the differences between occupied and unoccupied modes of operation.

.5 Reporting: Describe any reporting features such as alarms, if these are displayed on the screen.

.6 Green Initiative: Provide a section on the importance of occupant comfort and indoor air quality. Describe the energy conservation features of the classroom mechanical equipment.

4.3 EMERGENCY PROCEDURES SHEET

.1 This laminated sheet is to provide school maintenance staff with basic trouble shooting and manual override procedures to be followed under conditions of major mechanical failure. Items are to include:

.1 Thermostat or user interface failure
- Power problem ?
- Control panel still working?
- Etc.

.2 Control panel failure
- Power problem?
- How to manually position the mixing dampers
- How to manually override the fan
- Etc.

.3 Classroom extreme low temperature
- Control panel or furnace problem?
- How to manually close the outside air dampers
- How to manually engage heating (i.e. gas valve etc) and fan
- Etc.

5. Controller Hardware and Software

5.1 PROGRAMMABLE CONTROL UNIT (PCU) & INTELLIGENT THERMOSTAT

.1 The PCU is to be a single stand-alone, custom programmable (NOT simply configurable), native BACnet controller.

.2 Included interfaces to allow connection to a larger BACnet system via a network to share information, execute commands, or save/load database and control sequences from a Central Control Station and/or laptop computer. Provide ALL of the following:

.1 IEEE 802.3 Ethernet 10/100 Base T, BACnet over IP
.2 EIA-485 @ up to 76.8 kbps, BACnet MS/TP
.3 Serial EIA-232 BACnet PTP 38400kbbs minimum

.3 Memory capacity and point configuration to suit application plus one spare universal input and one spare analogue output.

.4 Watchdog timer. Failure of PCU shall automatically switch outputs to a pre-selected fail-safe condition.

.5 Real Time Clock function with programmable scheduling.

.6 Permanently marked removable terminal block for the wiring of all sensors, control devices, network and PCU power.

.7 Manual Hand/Off/Auto override switches for fans, gas valves, dampers and heat reclaim output points.

.8 Intelligent thermostat (net-sensor) with the following features as a minimum:
- .1 Screen capable of continuous display of operating mode, system status as well as outside and inside air temp to a resolution of 0.5 degC.
- .2 Four programmable buttons providing setpoint increase/decrease and occupied/unoccupied mode operation.
- .3 Additional keys and screen display functionality as required to provide access to setup and sequence configuration functions. Entry into setup mode shall be protected with some form of pass code.
- .4 Ability to set device to continuously display room setpoint or current room temperature.
- .5 Space temperature accuracy of +/- 0.3 degC.
- .6 Neutral colour, vented, metal or robust plastic, enclosure with base to cover wall opening.

.9 Each physical or virtual point, controller point or schedule, is to have a unique, user-definable, system-wide, logical point mnemonic. The format of these point mnemonics shall conform to the Alberta Infrastructure Guideline for Logical Point Mnemonics. Refer to control sequences for other relevant names.

5.2 PROGRAMMING/CONFIGURATION TOOL AND MANUALS

.1 One licensed software development tool must be provided with every classroom to allow the creation/modification/configuration/saving/reloading of all controller data bases and custom controls sequences, via a portable computer connected to the PCU. Include any required interface device/cable/hardware.

NOTE: If many high performance modular classrooms are being provided to one school division/board, then only provide development tools to a maximum of 3 complete packages. If the board already has the required software tools then only upgrade these packages to current version.

.2 Development tool to include a control sequence editor that:

- .1 has full screen editing of program source code.

.2 uses graphic display, drag-and-drop graphic representations and graphic linking of objects for block language type languages.

.3 automatically changes all program occurrences of a point mnemonic, if that point mnemonic is changed in data base.

.4 flags undefined point mnemonics if a point is removed from the data base.

.3 Development tool to provide facility to change the Ethernet address of any BACnet over IP Ethernet enabled classroom controller, as well as have the ability to change the controller's BACnet device instance. This is required when networking multiple BACnet controllers since only one unique BACnet device instance is allowed on a BACnet network.

.4 Include a development tool user's manual as well as a programming instruction manual listing all procedures, functions, operators and reserved words together with a description and examples of their use in programming.

6. Execution

6.1 OCCUPANCY AND LIGHT SENSORS / DEVICES

.1 Install TWO occupancy sensors, contacts wired in parallel. Sensors to be mounted high in back corners near the windowed wall. Sensor beams should cross and cover both possible blackboard locations. Sensing area must not include windows, ceiling or door out to hallway. Sensitivity to be adjusted so as to trigger on student or teacher movement but not to respond to normal heating, ventilating, air conditioning system warm or cold air movement. A single 360 degree, dual technology, ceiling mounted device may be considered if its performance can meet these requirements.

.2 If daylight harvesting is to be used, then have light sensors look down from ceiling in area that receives light from the windows, clearstory or other opening.

- .1 For a generic design, light sensors would be located approximately 3m in from the windows. For a clearstory or light tube, sensor should point down from ceiling in close proximity to lit area.
- .2 Lighting control zones to be coordinated with sensed areas.
- .3 Some form of daylight attenuation may be required if class is to be able to be darkened for AV presentations. These may be manual in nature.

6.2 WIRING AND INSTALLATION

.1 Wiring: to CSA C22.2 No. 75-M1983, copper conductor, 600 V RW90 X-link insulation. 300 V insulation allowed for conductors not entering enclosures containing line voltage.

.2 120 VAC Control Wiring: minimum #14 AWG.

.3 Low Voltage Field Wiring:

- .1 Minimum #22 AWG.
- .2 Twisted pairs.
- .3 Stranded, except #18 AWG and larger may be solid.
- .4 Shielded with drain wire, except for digital input/output wiring carrying less than 25mA and not installed in tray.
- .5 Multi-conductor wiring must have individually twisted and shielded pairs with a drain wire for each pair. Cable must have overall shield. Maximum 6 pairs.

.4 Plenum rated cable to be FT4 rated.

.5 Neatly arranged panduit with snap on covers shall be used to restrain wiring inside cabinets larger than 300mm square.

.6 Neatly train and cable tie wiring in cabinets smaller than 300 mm square. Adhesive backed twist ties or adhesive backed cable tie holders are not allowed. Wiring shall be secured to cabinet back with mountable cable ties fastened with #8 or larger sheet metal screws.

.7 Each field device shall have its own signal and return wire individually terminated in the panel. The use of a common return wire or ground for more than one control point is not allowed.

.8 Plenum rated cable shall be secured to the building structure at intervals not exceeding 2 meters. Attaching cable to the ceiling support system is not allowed.

.9 A single continuous non-spliced cable shall be used for connecting each field device.

6.3 IDENTIFICATION

.1 Use heat shrink sleeves, with printed or legible hand written identifier, OR factory coded slip-on identification bead markers or sleeves. Wrap-on adhesive strips are not allowed.

.2 Size of sleeves to be selected so that they do not slip off when wire is removed from termination and shaken.

.3 Wiring more than 1 meter in length must be labeled at both ends.

.4 Labels for all system point wiring shall, as a minimum, contain the following information:

  .1 Panel end: panel terminal number or hardware address.
  .2 Device end: panel number as well as panel terminal number or hardware address.

.5 Label panel power supply wiring with the panel connector number.

.6 Label communications port wiring with panel connector number and device name (e.g. “J1-modem”, “J2-printer”).

.7 Label communications trunk wiring with the panel number, router number etc. to which the other end of the cable is connected.

.8 Wiring on each side of a terminal block or splice shall be labeled with the information required for the device end of the wire.

.9 Identify all input sensors and output devices, actuators, motors and equipment, with laminated point tags containing the following information:

.1 Logical Point Mnemonic
.2 Point Hardware Address and connection terminal identifiers
.3 Associated System Identification
.4 Point Description

6.4 GROUNDING

.1 Provide a complete ground system for all PCU equipment, including panels, conductors, conduit, raceways, connectors and accessories. Grounding shall be by means of electrical supply conductor bonding method. Separate grounding conductors not permitted.

.2 Grounding between control panels and field devices shall have a star configuration. The shield for a field device shall be grounded at the panel only.

.3 The shield for communications wiring must be contiguous throughout its full length and shall be grounded at one point only. For intelligent thermostats, the ground shall be at the PCU. Splices shall expose no more than 2cm of unshielded wire.

6.5 SCHOOL INTERFACE CABINET AND TERMINAL STRIP

.1 Supply and install a 250m square, 100mm deep, junction box on the wall, 50mm above ceiling tile height on the hallway side of the classroom. Install one 10 position terminal strip and one RJ-45 Ethernet receptacle within the box and affix with #8 screws. Connect this junction box to the PCU cabinet with a 19mm EMT and a 13mm EMT.

.2 School interface strip: Provide separation between the output and input locations. Wire points to PCU and ensure shield and drain wires are taken back to PCU and terminated there. Affix a layout sheet on the door inside surface. Label locations as follows:

Wire pair #1:	Mechanical Alarm (relay output)
Wire pair #2:	Spare
Wire pair #3:	Time Clock (dry contact input)
Wire pair #4 + shield:	EIA-485 School Network (BACnet MS/TP) (Install termination resistor)

.3 Run communications wiring in 13mm EMT and input/output wiring in 19mm EMT.

6.6 TRAINING OF OPERATORS

.1 Provide ½ day factory training courses covering the following:

- .1 Tour of mechanical system and overview of system schematics, O&M Manual and Teacher's Guide.
- .2 Detailed explanation of operating modes and sequences of operation.
- .3 Method for changing setpoints, schedules and occupancy override.
- .4 Basic trouble shooting.
- .5 Very basic description of programming/configuration tool. Provide a list of all vendor's in Alberta that can provide post warrantee service on the supplied controls.

.2 Class size should not be more than 20. Provide a sign off sheet, for inclusion in the system documentation manuals.

.3 Training must be performed at Alberta location on a fully functional classroom identical to owner's units. Provide option for on-site training.
Note: No cost on-site training should be offered to boards that have purchased a number of high performance modular classrooms. Perhaps one session per 10 units purchased.

.4 Although not related to controls, training should include a few words on proper site preparation and classroom installation.

6.7 MISCELLANEOUS

.1 Programming/Configuration tool Manuals, O&M Manual, Disk, Backup Package and two copies of the Teacher's Guide to be stored in a lockable cabinet in the mechanical space. Label cabinet with "MANUALS". Two copies of the Teacher's Guide to be stored in a pouch mounted on the front surface of the cabinet.

END OF GUIDELINE

Relocatable Classrooms - *SAMPLE* Point Sheet

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Systems: RC##

"Januaryr 2009

No.	Description	Label	DI	DO	AI	AO	Group	Remarks
1	Pkg Alarm (Flame Fail etc)	RC## FAULT	Dc				A	
2	Supply Fan Continuous Operation	RC## SF		Ry			A	Include HOA
3	Exhaust Fan	RC## EF		Ry			B	Include HOA
4	Humidifier Solonoid etc.	RC## HF		Ry			B	
5	Gas Valve Low Fire (2 stage)	RC## LF		Ry			A	1st stage of heating: NOTE A (Include HOA)
6	Gas Valve High Fire (2 stage)	RC## HF		Ry			A	2nd stage of heating: NOTE A (Include HOA)
7	Gas Valve (Modulating)	RC## GV				Vm	A	Modulating gas valve: NOTE A (Include HOA)
8	DX Cooling	RC## CLG		Ry			B	Do not allow activation below 15 degC OAT
9	Mixed Air Temperature	RC## MAT			Tp		A	Locate in well mixed portion of air stream
10	Supply Air Temperature	RC## SAT			Tp		B	Locate in supply duct
11	Mixed Air Dampers	RC## MAD				Dm	A	Belimo or equivalent actuators (Include HOA)
12	Relief Air Damper	RC## RAD				Dm	A	Belimo or equivalent actuators (Include HOA)
	Net-Sensor / User Interface							
13	Timed Occupancy Manual Override Switch	RC## OCCMOR	Dc				A	
14	Space Temperature	RC## ST			Tr		A	Locate on classroom side of mech room wall
15	Space Relative Humidity	RC## RH			Hr		B	Locate on classroom side of mech room wall
16	CO2 Concentration	RC## CO2			Co2		B	Carbon dioxide concentration PPM
	Miscellaneous							
17	Occupancy Sensor	RC## OCCS	Os				A	Mount to view blackboard and front desks
18	Room Lights	RC## L		Ry			B	N/C contact, Interupt power to switches
19	Sump High Level Alarm	RC## SUMP-HI	Dc				B	
20	Mechanical Alarm	RC## MALM		Ry			A	Wire to school interface terminal strip
21	Time Clock	RC## TC	Dc				A	Wire to school interface terminal strip
22	Outside Air Temperature	RC## OAT			To		A	Mount in fresh air intake
23	Spare AI Input	RC## Spare1			Spare		B	Spare universal input point
24	Spare AO Output	RC## Spare2				Spare	B	Spare universal output point (Include HOA)
	Total this System		**5**	**8**	**7**	**4**		**24**

NOTE A : All heating unit safety interlocks to remain. Gas valve type to be determined during system design

NOTE: All points under same group letter must be in same control panel.