Part 1 General

1.1 PROGRAMMING

.1 Sequences, procedures and programs described in "Execution" part of the current section represent minimum operation criteria, omitting small details required for system fine tuning. The suppliers for the current section is responsible for programming and must, as an expert in the commissioning of this type of installation, provide all control stratagems, including delays, ramps, readjustments, locking, nesting loop, etc., in order to have a secure operation, simple and efficient systems.

.2 Any modification, addition or required refinements for systems stability or equipment protection by Departmental Representative will have to be executed at no charge.

1.2 CONFIGURATION AND CUSTOMIZATION

.1 System configuration and customization to be executed in collaboration with Departmental Representative in order to allow an easy transfer to operation team.

.2 Messages, descriptions, equipment key-words, etc., have to be submitted for approval. Control contractor must use the same symbols and identifications appearing on existing shop drawings.

.3 Choice of colors, disposition on screen, systems repartition, tree structure (level of intrusion) and graphic configuration is done in coordination with Departmental Representative.

.4 Making of reports, headers, presented information and its disposition, printing frequency and period, etc., are done in coordination with Departmental Representative.

1.3 CRITERIA

.1 Set point, parameters and constants:

1. All set points, rates and compensation limits are adjustable by the operator according to his access level.
2. In the same manner, all the parameters, constants, programmed delays are re-adjustable by the operator having the right access level.

.2 Analog alarms:

1. For each point of analog reading, program high and low-limit alarms.
2. These set points should be resetable and the alarms cancelled if required by the operator.

.3 Critical alarms:

1. When the status is available, program critical alarms for the following points:
   - .1 Unauthorized on-off.
   - .2 Fault (equipment).
   - .3 Maintenance alarms

.2 When the status is available, program maintenance alarms for the following:

.1 System stopped.

.2 Running time.

Part 2 Sequences of Operation

2.1 CHILLER

.1 Description:

.1 Chilled water is supplied at 6.6 ˚C year round to cool the simulator cabin HVAC units in the main building, the computer room air conditioning unit in the main building, the hydraulic pumping units in the hydraulic building, and two 5-ton air conditioning units in the hydraulic building for removing waste heat generated by the large hydraulic pumping unit motors.

.2 The chiller plant consists of a modular chiller comprised of two modules each with 2 stages of refrigeration per module. Roof-top mounted fluid coolers DC-01 and DC-02 act as condensers in the summer, and provide free-cooling in the winter. The chilled water pumps are arranged in a duplex fully redundant configuration, and are equipped with variable frequency drives (VFDs) for capacity control. A control valve in the piping system acts as a system bypass in the event the VFD is reduced to minimum speed and further capacity reduction is necessary.

.3 The entire system consists of 50% propylene glycol, allowing winter-time free-cooling to be performed without the use of a heat exchanger. Control valves are used switch over to free cooling either automatically based on sustained outdoor air temperatures, or upon manual request from the Operator.

.4 Duty rotation of the chiller modules, chilled glycol pumps, and fluid coolers is automatic, controlled by the Building Automation System (BAS).

.5 During the winter, the fluid coolers provide free cooling during which time the chillers are bypassed and the condenser pumps P1 and P2 are not used. Free-cooling is selected either automatically or manually depending on the preference of the Operator. A control at the Operator Workstation shall allow selection of automatic or manual changeover between free and mechanical cooling.

.2 Seasonal Transition (Free Cooling Mode and Mechanical Cooling Mode):

.1 Automatic seasonal transition, Free-cooling mode, and Mechanical cooling mode are all operator selectable from a graphic control at the operator workstation.

.2 Under automatic seasonal transition:

.1 When the system has been in Free-cooling Mode, and the average outdoor temperature has risen above 8˚C (adjustable) for more than 12 hours (adjustable), the seasonal mode is switched automatically by the BAS from Free Cooling Mode to Mechanical Cooling Mode. An informative, high priority alarm is sent to the operator workstation.

.2 When the system has been in Mechanical-cooling Mode, and the average outdoor temperature has dropped below 5˚C (adjustable) for more than 12 hours (adjustable), the seasonal mode is switched automatically by the BAS from Mechanical Cooling Mode to Free-cooling Mode. An informative, high priority alarm is sent to the operator workstation.

.3 Stopped:

.1 Fluid cooler pumps P1 and P2 are stopped.

.2 Chilled water pumps P3A and P3B are stopped.

.3 The chiller is disabled and chiller selection valves CV-1 and CV-2 are closed.

.4 Bypass valve CV-3 is closed.

.5 The fluid cooler fans are stopped and fluid cooler selection valves CV-5 and CV-6 are open.

.4 Start-up:

.1 The lag duty fluid cooler selection valve (CV-5 or CV-6) is commanded closed, and the fluid cooler condenser pump (P1 or P2) associated with the lead chiller module is started. The fluid cooler runs for a period of 10 minutes to allow the glycol temperature to stabilize.

.2 Mechanical-cooling Mode:

.1 Free-cooling 3-way control valve CV-4 is diverting the building return glycol towards the suction of the chilled glycol pumps P-3A and P-3B.

.2 The lead chilled water pump (P3A or P3B) is started. The selected pump is ramped to 50% speed over a period of 3 minutes. Following the initial ramping period, the pump is modulated at a maximum rate of 4% change per minute via its VFD in order to maintain the differential pressure in the glycol piping at the mechanical cooling mode target set-point of 55 kPa (adjustable, to be determined during initial hydraulic balancing). The glycol bypass valve CV-3 is continually modulated as required to maintain glycol flow CGLY-F through the chiller at the set-point of 5.7 L/sec at all times.

.3 Free-cooling Mode:

.1 Free-cooling 3-way control valve CV-4 is diverting the building return glycol towards the roof-top mounted fluid-coolers.

.2 The chiller remains disabled.

.3 The lead chilled water pump (P3A or P3B) is started. The selected pump is ramped to 50% speed over a period of 3 minutes. Following the initial ramping period, the pump is modulated at a maximum rate of 4% change per minute via its VFD in order to maintain the differential pressure in the glycol piping at the free cooling mode target set-point of 65 kPa (adjustable, to be determined during initial hydraulic balancing). During periods of light load when the VFD has reduced to 30% capacity, glycol bypass valve CV-3 is continually modulated as required to maintain differential pressure at all times. The flow-meter is not used.

.5 Normal Operation (Mechanical-cooling Mode):

.1 The DDC controller commands the fluid cooler stages in sequence to maintain the condenser water return temperature (C-TR) at the set-point temperature of (C-TR-SP). The condenser water return temperature is continuously reset according to the outdoor air temperature as follows:

OAT	**C-TR-SP**
37.2 ˚C	**40.6 ˚C**
15.6 ˚C	**26.7 ˚C**

.2 The fluid cooler stages are activated on a first-on, first-off basis to provide equal run demand.

.3 The DDC controller commands the stages of the lead chiller module in sequence to maintain the chilled glycol supply temperature (CGLY-TS) at the permanent set-point temperature of 6.6 ˚C. The chiller module selection valves are opened and closed automatically by the chiller's internal controls.

.6 Normal Operation (Free-cooling Mode):

.1 The DDC controller commands the fluid cooler stages in sequence to maintain the condenser water return temperature (C-TR) at the set-point temperature of 6.6 ˚C.

.2 The fluid cooler stages are activated on a first-on, first-off basis to provide equal run demand.

.3 If the Outdoor Air Temperature (OAT) is above 2˚C (adjustable), the lag fluid cooler selection valve (CV-5 or CV-6) is permitted to open, and all 8 stages of fan cooling are available (4 pairs of fans per fluid cooler). These are staged as required to maintain the condenser water return temperature (C-TR) at the set-point temperature of 6.6 ˚C. During this condition, the 1st fan stage of the lag fluid cooler is considered the 5th stage overall for the purposes of staging between the two fluid coolers. Once the Outdoor Air Temperature (OAT) drops below -5˚C (adjustable), the lag fluid cooler selection valve (CV-5 or CV-6) is closed, and the normal staging method resumes, with only the lead fluid cooler in service.

.7 Transition from Mechanical Cooling Mode to Free-cooling Mode:

.1 Upon a transition to Free-cooling Mode:

.1 The condenser circuit is pre-cooled as much as possible prior to stopping the chiller:

.1 The selection valve associated with the lag fluid cooler (CV-5 or CV-6) is opened.

.2 All the fluid cooler fans are turned on simultaneously.

.3 Once the condenser return temperature (C-TR) reaches 23.8 ˚C:

.1 The chiller module is stopped (disabled).

.2 Free -cooling 3-way control valve CV-4 is stroked to divert the building return glycol towards the roof-top mounted fluid-coolers.

.3 The rapid cooling of the glycol (all 8 stages of fan cooling in operation) continues until the condenser return temperature reaches 10 ˚C (adjustable). At that time, the fan staging (number of fluid coolers and staging) resumes the normal sequence as described previously (see Normal Operation (Free-cooling Mode).

.8 Transition from Free-cooling Mode to Mechanical Cooling Mode:

.1 Upon a transition to Mechanical Cooling Mode:

.1 The condenser circuit is pre-heated as much as possible prior to starting the chiller:

.1 The fluid cooler stages are all turned off.

.2 The selection valve associated with the lag fluid cooler (CV-5 or CV-6) is closed if open prior to the transition.

.3 The glycol circuit is left to circulate until either 10 minutes (adjustable) lapses, or the return glycol temperature CGLY-TR reaches 20 ˚C (adjustable).

.2 Free-cooling 3-way control valve CV-4 is stroked to divert the building return glycol towards the suction of the chilled glycol pumps P-3A and P-3B.

.3 The fluid cooler condenser pump (P1 or P2) associated with the lead chiller module is started.

.4 The lead chiller module is started.

.5 The fluid cooler fan staging for Normal Operation (Mechanical-cooling Mode) as described previously resumes.

.6 The chiller module compressor staging for Normal Operation (Mechanical-cooling Mode) as described previously resumes.

.9 Duty Rotation:

.1 Chiller Modules:

.1 The lead duty and lag duty chiller module are reversed automatically on a weekly basis.

.2 The lead duty and lag duty condenser pumps (P1 or P2) are also reversed automatically so that the lead condenser pump is at all times associated with the lead chiller module, and vise-versa.

.3 The transition shall be programmed occur during business hours, on a weekday.

.2 Chilled Glycol Pumps:

.1 The lead duty and lag duty pump (3A or 3B) are reversed automatically on a weekly basis. The rotation shall be programmed occur during business hours, on a weekday.

.3 Fluid Coolers:

.1 Mechanical Cooling Mode:

.1 The lead duty and lag duty fluid cooler (DC-01 or DC-02) are reversed automatically on a weekly basis so that the lead duty fluid cooler is at all times associated with the lead condenser pump (P1 or P2), and vice versa.

.2 The rotation shall be programmed occur during business hours, on a weekday.

.2 Free-Cooling Mode:

.1 During free-cooling, the possibility of thick stagnant glycol due to cold ambient temperatures exists.

.2 The rotation shall be programmed occur during business hours, on a weekday.

.3 If the outdoor temperature is below -15 ˚C, the rotation is cancelled, and an informative low priority alarm is raised at the operator workstation.

.4 The rotation to the new lead fluid cooler is performed slowly, in order to allow the cold slug of outdoor glycol to warm up:

.1 Over a period of 15 minutes (adjustable), the selection valve for the new lead duty fluid cooler is ramped from the closed position to the open position.

.2 During this time, the selection valve for the new lag duty fluid cooler is simultaneously closed.

.3 During this time, the fan stages in both fluid coolers are staged as required to maintain the condenser return temperature (C-TR) at 6.6 ˚C.

.10 Abnormal Operation:

.1 Chiller Modules:

.1 In the event a chiller fault occurs is detected, a high priority alarm is raised, a message is issued at the Operator workstation, and the lead/lag duty roles of the two chiller modules are reversed:

.1 The condenser pump (P1 or P2) associated with the new lead chiller is started.

.2 The new lead duty chiller module is automatically started.

.2 Chilled Glycol Pumps:

.1 In the event a pump or VFD fault (command/status conflict), a high priority alarm is raised, a message is issued at the Operator workstation, and the lead/lag duty roles of the two pumps P1A and P1B are reversed.

.1 The new lead duty chiller pump is automatically started and maintains flow as per the sequence detailed previously.

.3 Fluid Coolers:

.1 At all times when the fluid coolers are operational, the number of fan stages in services are verified by comparing the total current draw to each dry-cooler against the look-up value recorded and programmed during initial

Testing, Adjusting, and Balancing (TAB) for all possible conditions (1 stage in service, 2 stages in service, and so on). A fluid cooler fault is detected in the event of a mismatch between the predicted and actual current values. In the vent of a fluid cooler fault:

.1 Mechanical Cooling Mode:

.1 If the temperature C-TR continues to be accurately maintained at the set-point C-TR-SP, then a high priority alarm is raised, and an informative message is issued at the Operator workstation. The affected fluid cooler remains in service

.2 If the temperature C-TR has risen above the set-point C-TR-SP, then the lead duty and lag duty fluid cooler (FC-01 or FC-02) are reversed automatically. The new lead duty dry cooler is automatically selected (control valve CV-5 or CV-6 opens), and the temperature control sequence is assumed by the new fluid cooler as described previously. The new lag fluid cooler (the faulty one) is removed from service (control valve CV-5 or CV-6 is closed). A high priority alarm is raised, and an informative message is issued at the Operator workstation.

.3 Free Cooling Mode:

.1 If the temperature C-TR continues to be accurately maintained at the set-point C-TR-SP, then a high priority alarm is raised, and an informative message is issued at the Operator workstation. The affected fluid cooler remains in service.

.2 If the temperature C-TR has risen above 7 ˚C (adjustable); then the lag fluid cooler selection valve (CV-5 or CV-6) is permitted to open, and all 8 stages of fan cooling become available. These are staged as required to maintain the condenser water return temperature (C-TR) at the set-point temperature of 6.6 ˚C. A high priority alarm is raised, and an informative message is issued at the Operator workstation.

.4 Condenser Pumps (P2 or P3):

.1 In the event of a command/status conflict, then a high priority alarm is raised, a message is issued at the Operator workstation, and the lead/lag duty roles of the two chiller modules are reversed.

.1 The lag condenser pump (P1 or P2) associated with the new lead chiller is started.

.2 The new lead duty chiller module is automatically started.

.5 General:

.1 In the event of any temperature or other operating parameter (flow, current, commanded or actual VFD speed) going out of range, a high priority alarm is raised, and a message is issued at the Operator workstation.

.6 Power Failure:

.1 All controllers and sensors are powered from emergency power.

.2 The status of the emergency power is monitored. In the event of operation (or resumption of operation following a power failure), the control functions of the entire chilled water plant must resume to the state previously held prior to the power failure.

2.2 HYDRAULIC BUILDING FAN-COILS AC-01 AND AC-02

.1 Description:

.1 Fan-coil units AC-01 and AC-02 run continuously. At times when there is no cooling requirement, the fan will shut off automatically.

.2 Stopped:

.1 The fan is off.

.2 The cooling valves CV-6 (AC-01) and CV-7 (AC-02) are closed.

.3 Start-up:

.1 When both units have been off and the room temperature in the Hydraulic Building rises above 28 ºC (adjustable), the fan of the lead fan-coil is started.

.4 Normal Operation:

.1 The cooling valve of the lead duty fan-coil (CV-6 or CV-7) modulates as required to maintain the room temperature at the set-point of 25 ºC (adjustable).

.2 If the cooling valve of the lead duty fan-coil is fully open and the cooling demand persists, the lag duty fan-coil is started. When the 2nd fan-coil starts, both cooling valves CV-6 or CV-7 are driven to 50% open and the room temperature is allowed to stabilize for 2 minutes (adjustable). With both fan-coils running, the lead duty cooling valve is opened first upon a demand for more cooling, then the lag duty valve if opened from 50% once the lead duty valve reaches the 100% open position. Similarly, upon a falling room temperature, the lag duty valve is closed first until it reaches the 50 % open position. If the cooling demand is further diminished, the lead duty valve begins to close from the 100% position. If the cooling demand continues to diminish, the lag duty fan-coil is turned off once the lead duty valve reaches the 40% position. At this time the lead duty valve is held at the 40% position for a 2 minute (adjustable) stabilization period.

.5 Abnormal Operation:

.1 The following conditions cause a critical priority alarm:

.1 Room high temperature of 30 ºC or higher.

.2 Command/status conflict of the run condition of either fan (fan failure or failure to start)

.6 Duty Rotation:

.1 At all times, one fan-coil AC-01 or AC-02 is the lead fan-coil, the other one is responsible for lag duty.

.2 Once every week, the duty is rotated between the two, in order to equalize wear and tear.

2.3 MAIN-BUILDING ROOFTOP-UNIT RTU-1

.1 Description:

.1 The existing rooftop unit RTU-1 will replaced with an identical variable volume unit consisting of:

.1 A return air and outdoor air mixing section with outdoor air, mixing and relief air dampers.

.2 Filter section.

.3 Glycol heating coil.

.4 DX cooling (4 stages) with evaporator coil and air-cooled condenser.

.5 Return fan with factory supplied VFD.

.6 Supply fan with factory supplied VFD.

.2 The existing humidifier distributor section will be retained in the existing ductwork, but the electrode type steam generator will be replaced.

.2 Stopped:

.1 The supply fan is off.

.2 The return fan is off.

.3 The humidifier is off.

.4 The outdoor air damper is closed.

.5 The relief air damper is closed and the mixing damper is open.

.6 If the outdoor air temperature is less than -5 ºC (adjustable), the glycol heating coil circulator pump is on.

.3 Start-up:

.1 The air handling unit runs on schedule, user configurable from the operator workstation. Set the initial schedule for start-up at 5:00 AM every day, with weekday shutdown at 11:00 PM, and weekend shutdown at 8:00 PM.

.2 A graphic hand-off auto selector shall be provided at the operator workstation.

.3 Upon a start command:

.1 The dampers remain in their stopped position.

.2 The supply and return fans are ramped gradually from stopped to 40% speed over a 2 minute (adjustable) ramping period.

.3 Once the ramping period has lapsed, the supply fan VFD is allowed to modulate fan capacity as required in order to maintain duct static pressure at the remote duct static pressure sensor at its set-point value of 250 Pa (adjustable).

.4 Once the ramping period has lapsed, the return fan VFD is allowed to modulate fan capacity in order to maintain return flow as measured by the fan inlet airflow measuring station according to a target supply-return differential of 800 L/s (adjustable). The airflow differential is determined continuously as the sum of all VAV flows minus the measured return air flow.

.4 Normal Operation:

.1 Cooling Mode:

.1 During cooling mode, the outdoor air dampers are held at their minimum outdoor air position. The relief air and mixing air dampers are modulated on the same signal as required to maintain a positive pressure in the relief air section of the unit relative to the supply fan suction side of the mixing damper. The set-point for this pressure differential is 5 Pa (adjustable).

.2 The supply air temperature SAT is maintained at a set-point value SAT-SP according to a reset schedule based on outdoor air as follows:

OAT	**SAT-SP**
18 ˚C	**16 ˚C**
35 ˚C	**13.8 ˚C**

.3 The supply air temperature set-point is SAT-SP further reset based on the demand by gradually resetting SAT-SP higher until 10% (adjustable) of all of the VAV boxes in the building have reached their maximum scheduled flow.

.4 The stages of DX compressor cooling are modulated in sequence as required to maintain the supply air temperature set-point SAT at the set-point SAT-SP.

.2 Heating Mode:

.1 Damper control is the same as for cooling mode.

.2 The supply air temperature SAT is maintained at a set-point value SAT-SP according to a reset schedule based on outdoor air as follows:

OAT	**SAT-SP**
-10 ˚C	**20 ˚C**
-35 ˚C	**24 ˚C**

.3 The heated glycol control valve is modulated as required in order to maintain the supply air temperature at the set-point value.

.3 Economizer Mode:

.1 The supply air temperature (SAT) shall be maintained at the cooling setpoint SAT-SP my modulating the intake, relief, and mixing damper whenever the outdoor air dry-bulb temperature is between -8 ˚C and 14 ˚C (adjustable).

.2 During economizer mode, the mixing plenum pressurization control sequence is cancelled.

.4 The humidifier is controlled to maintain indoor relative humidity levels according to outdoor air temperature:

.1 The return air relative humidity RARH is maintained at a set-point value RARH-SP according to a reset schedule based on outdoor air as follows:

OAT	**RARH-SP**
0 ˚C	**30 %**
-35 ˚C	**17 %**

.5 Abnormal Operation:

.1 The following conditions cause a critical priority alarm:

.1 Command/status conflict of the run condition of either supply or return fan (fan failure or failure to start).

.2 VFD alarm of a fault nature.

.3 The unit is shut off on low temperature by its freeze-stat.

2.4 SIM BAY ROOFTOP-UNIT RTU-2

.1 Description:

.1 The existing rooftop unit RTU-2 will replaced with an identical constant volume unit consisting of:

.1 A return air and outdoor air mixing section with outdoor air, mixing and relief air dampers. The relief air damper is gravity type.

.2 Filter section.

.3 Glycol heating coil.

.4 DX cooling (3 stages) with evaporator coil and air-cooled condenser.

.5 Supply fan.

.2 The existing humidifier distributor section will be retained in the SIM bay, but the electrode type steam generator will be replaced.

.2 Stopped:

.1 The supply fan is off.

.2 The humidifier is off.

.3 The outdoor air damper is closed.

.4 The mixing damper is open.

.5 If the outdoor air temperature is less than -5 ºC (adjustable), the glycol heating coil circulator pump is on.

.3 Start-up:

.1 The air handling unit runs on schedule, user configurable from the operator workstation. Set the initial schedule for start-up at 5:00 AM every day, with weekday shutdown at 11:00 PM, and weekend shutdown at 8:00 PM.

.2 A graphic hand-off auto selector shall be provided at the operator workstation.

.3 Upon a start command:

.1 The dampers remain in their stopped position.

.2 The supply fan is ramped gradually from stopped to full speed over a 3 minute (adjustable) ramping period.

.3 Once the ramping period has lapsed, the outdoor air and mixing dampers are set to their nominal minimum air position determined during TAB.

.4 .Normal Operation:

.1 Cooling Mode:

.1 During cooling mode, the outdoor air dampers are held at their minimum outdoor air position. The outdoor air and relief dampers are modulated as required to produce the minimum possible outdoor air amount required to maintain the return air CO2 level at a maximum value of 800 ppm (adjustable).

.2 The supply air temperature SAT is maintained at a steady set-point of 22 ˚C at all times.

.3 The stages of DX compressor cooling are modulated in sequence as required to maintain the supply air temperature set-point.

.2 Heating Mode:

.1 The supply air temperature SAT is maintained at a steady set-point of 22 ˚C at all times.

.2 The heated glycol control valve is modulated as required in order to maintain the supply air temperature at the set-point value.

.3 Economizer Mode:

.1 The supply air temperature (SAT) shall be maintained at the cooling setpoint SAT-SP my modulating the intake, relief, and mixing damper whenever the outdoor air dry-bulb temperature is between -4 ˚C and 20 ˚C (adjustable).

.4 The humidifier is controlled to maintain indoor relative humidity levels according to outdoor air temperature:

.1 The return air relative humidity RARH is maintained at a set-point value RARH-SP according to a reset schedule based on outdoor air as follows:

OAT	**RARH-SP**
0 ˚C	**30 %**
-35 ˚C	**17 %**

.5 Abnormal Operation:

.1 The following conditions cause a critical priority alarm:

.1 Command/status conflict of the run condition of the supply fan (fan failure or failure to start).

.2 VFD alarm of a fault nature.

.3 The unit is shut off on low temperature by its freeze-stat.

2.5 ADDITION ROOFTOP-UNIT RTU-3

.1 Description:

.1 The existing rooftop unit RTU-3 will retained, and upgraded slightly with some additional controls. The unit consists of:

.1 An energy recovery wheel with bypass.

.2 Filter section on the energy recovery wheel and cooling coil.

.3 Natural gas heating section.

.4 DX cooling (2 stages) with evaporator coil and air-cooled condenser.

.5 Exhaust fan with factory supplied VFD.

.6 Supply fan with factory supplied VFD.

.2 Stopped:

.1 The supply fan is off.

.2 The exhaust fan is off.

.3 The energy recovery wheel is off (by RTU internal control).

.3 Start-up:

.1 The air handling unit runs on schedule, user configurable from the operator workstation. Set the initial schedule for start-up at 5:00 AM every day, with weekday shutdown at 11:00 PM, and weekend shutdown at 8:00 PM.

.2 A graphic hand-off auto selector shall be provided at the operator workstation.

.3 Upon a start command:

.1 The supply and return fans are ramped gradually from stopped to 40% speed over a 2 minute (adjustable) ramping period.

.2 Once the ramping period has lapsed, the supply fan VFD is allowed to modulate fan capacity as required in order to maintain duct static pressure at the remote duct static pressure sensor at its set-point value of 250 Pa (adjustable).

.3 Once the ramping period has lapsed, the exhaust fan VFD is allowed to modulate fan capacity in order to control maintain a neutral or slightly positive building pressure relative to the outdoor, as measured by the new building static pressure sensor to be installed.

.4 The energy recovery wheel is controlled under the internal controls of the rooftop unit manufacturer, including defrost mode during heating mode.

.4 Normal Operation:

.1 Cooling Mode:

.1 The cooling compressor control shall be staged as follows: the variable capacity stage shall first be enabled then modulated from minimum to maximum capacity as required to maintain the discharge air temperature value at set-point. As required, the second stage shall be enabled, and the variable capacity stage modulated from its minimum capacity. In this

fashion, the supply air temperature SAT is maintained at a set-point value SAT-SP according to a reset schedule based on outdoor air as follows:

OAT	**SAT-SP**
18 ˚C	**17 ˚C**
35 ˚C	**13.8 ˚C**

.2 The supply air temperature set-point is SAT-SP further reset based on the demand by gradually resetting SAT-SP higher until 10% (adjustable) of all of the VAV boxes in the building have reached their maximum scheduled flow.

.2 Heating Mode:

.1 When the outdoor air temperature is less than 10 C (adjustable), the natural gas heating section is enabled.

.2 The supply air temperature SAT is maintained at a set-point value SAT-SP according to a reset schedule based on outdoor air as follows:

OAT	**SAT-SP**
0 ˚C	**20 ˚C**
-35 ˚C	**24 ˚C**

.3 The natural gas heating section reset signal sent to the RTU terminal strip is modulated as required in order to maintain the supply air temperature at the set-point value.

.5 Abnormal Operation:

.1 The following conditions cause a critical priority alarm:

.1 Command/status conflict of the run condition of either supply or exhaust fan (fan failure or failure to start).

.2 VFD alarm of a fault nature.

.3 The unit is shut off on low temperature by its freeze-stat.

.4 Clogged filter, phase loss, or brown-out.

2.6 ADDITION ROOM TEMPERATURE CONTROL

.1 Description:

.1 The addition is currently heated with radiant system consisting of PEX tubing run through the slab. Heat is applied to this system by a wall-hung natural gas fired boiler. Six radiant slab zones are heated under the control of six zone valves.

.2 In this project the system will not be modified, other than the addition of supply and return water temperatures in the piping to and from the radiant slab.

.3 The sequence of operations will be altered in order to eliminate the potential for fighting between the VAV boxes and the slab.

.2 Stopped:

.1 The boiler is off.

.2 The radiant system pump circulating water to the slab is off.

.3 The three way control valve for controlling slab temperature is closed to the boiler.

.3 Start-up:

.1 The boiler is started manually by the building operator.

.2 When the outdoor air temperature drops below -5 C (adjustable) the pump circulating water to the slab is started.

.3 When the outdoor air temperature has risen above 5 C (adjustable) for more and remained above this temperature for more than 12h, the pump is stopped.

.4 .Normal Operation:

.1 Heating Mode:

.1 The valve is modulated so as to maintain the slab supply water temperature (SWT) at a set-point (SWT-SP). The set-point shall be reset automatically as a function of the outside air temperature as follows:

OAT	**SWT-SP**
-5 ˚C	**30 ˚C**
-35 ˚C	**40 ˚C**

.2 The control valve shall always respond very slowly to changes in the outdoor air temperature, changing the valve position at a maximum of 4% valve travel per hour.

.3 Perimeter Zones (Radiant zones 1, 3, 4, 5):

.1 Once the first of any of the VAV boxes of these zones have reached minimum position, zone valve is opened. The valve remains open for as long as the box is on minimum position.

.2 During heating, the radiant zone valve does not respond to room temperature. Only the fan-coil or reheat coil serving the zone is modulated.

.3 Once the fan-coil or reheat coil serving the zone is closed and the VAV box is about to open, only then is the radiant zone valve closed.

.4 Interior Zones (Radiant zones 2, 6):

.1 Once the first of any of the VAV boxes of these zones have reached minimum position, zone valve is opened.

.2 The zone valve is cycled open and closed according to the room sensor demand for heat.

2.7 MAIN BUILDING ROOM TEMPERATURE CONTROL

.1 Description:

.1 There are a variety of spaces, interior and perimeter. Perimeter zones are heated by fan-coils. See control schematics for the sequences required in each case.

.2 Normal Operation:

.1 Heating Mode:

.1 New command relays will be used to start the perimeter fan-coils when a demand for heat exists. The fan-coils shall be started once perimeter heating is required by the specific room condition (as indicated).

END OF SECTION