1 General

1.1 SUMMARY

.1 Section Includes:

.1 Programming and configuration of site-specific requirements for sequences of operation to meet the Project's operational criteria.

.2 Work results related to Division 25. Sequences of operation described in this section solely relate to physical and logical points under control and supervision of the integrated automation system.

.1 Third-party systems and packaged equipment with built-in controls are assumed to be provided with preprogrammed routines or configurable operating modes with which the integrated automation system interacts.

.2 Achieving a fully functional system compliant with the described sequences of operation extends beyond programming. It may include providing hardwire interlocks, adjusting instrument and control device settings, and modifying configuration parameters in third-party systems or equipment.

.1 Work specified in this section closely relates to equipment and work results specified in other sections of Division 25. Read this section in conjunction with:

.1 The System Architecture Diagram provided on Drawings, showing requirements for systems and equipment to communicate and exchange data.

.2 Instrumentation and control device requirements in other sections.

1.2 RELATED REQUIREMENTS

.1 Section 25 01 11 – EMCS: Start -Up, verification and Commissioning.

.2 Section 25 05 010 – EMCS: General Requirements

.3 Section 25 30 01 – EMCS: Building Controllers

1.3 REFERENCE STANDARDS

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

.1 ASHRAE Guideline 36-2021, High Performance Sequences of Operation for HVAC Systems

.2 ASHRAE/IES 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings

1.4 ADMINISTRATIVE REQUIREMENTS

.1 Coordination:

.1 Integrated Systems: Coordinate system interfaces connecting to integrated automation equipment with other Subcontractors, manufacturers, and suppliers to verify compliance with intended sequences of operation.

.2 Review submittals of third-party equipment and notify the representative consultant when the proposed interface will affect the intended sequences of operation.

.3 Review third-party products and coordinate with trades to resolve integration issues and propose corrections.

.2 Coordinate with Section 25 30 01 – Building Automation Controllers for software requirements.

1.5 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit sequences of operation during Shop Drawing review in accordance with Section 01 33 00 – Submittal Procedures and Section 25 05 02-EMCS: Submittals and Review Process.

.2 Integrated Systems: Submit proposed changes to system interface and sequences of operation to the representative of consultant for review.

1.6 CLOSEOUT SUBMITTALS

.1 Submit in accordance with Section 01 78 00 – Closeout Submittals and Section 25 05 01 – EMCS: General Requirements.

.2 Record Documentation: Submit recorded changes made to sequences of operation during construction and commissioning activities in accordance with Section 25 05 01 – EMCS: General Requirements.

.1 Submit a copy of sequences of operation in Microsoft Word format so changes can be made and saved by Owner's personnel. Protect files to prevent modifications by unauthorized users.

1.7 QUALITY ASSURANCE

.1 Qualifications:

.1 Programmers: Personnel specialized in configuring and commissioning this type of installation with five years of experience.

.2 Programmers to provide all control stratagems to ensure systems operate in a safe and efficient manner. Include delays, ramps, reset functions, interlocks, and cascade loops.

2 Products

2.1 NOT USED

.1 Not used.

3 Execution

3.1 PROGRAMMING CRITERIA

.1 Incorporate the following programming criteria when programming the sequences of operation:

.1 Setpoints, Schedules, and Calendars:

.1 Provide ability to adjust setpoints, schedules, and calendars without requiring program modifications.

.2 Operations and maintenance (O&M) staff with proper authorization levels can adjust setpoints, schedules, and calendars.

.3 Determine optimal setpoints, hours of operation, and calendar during commissioning phase, and complete adjustments.

.2 Operation Modes, Parameters, and Constants:

.1 Operator personnel with proper authorization level to have the ability to switch operating modes (such as occupied or unoccupied) and modify parameters, constants, and time delays without requiring programming modifications.

.3 Control Loops:

.1 Provide proportional and integral (PI) type control loops except as follows:

.1 Flow and pressure control loops: Proportional, integral, and derivative (PID) type.

.2 Limit control loops: Proportional type.

.2 Adjust control loops to provide stable operating system during extreme conditions.

.4 Starting Ramps:

.1 Incorporate control ramps during system start-up, or after a setpoint adjustment, to gradually bring control points to their setpoint values, preventing risks such as freezing, low pressure, and high pressure.

.2 Incorporate additional control ramps required for system operation or as requested by the representative of consultant during start-up and commissioning.

.3 All control ramp rates to be adjustable.

.5 Alarms and Events:

.1 Alarm messages: Include timestamp, date, alarm level and description, equipment tags for involved components, and potential alarm trigger.

.2 Sensor failure: When a sensor failure is detected, the system is to disable the associated input point and transition dependent control points to a safe state.

.3 Alarm suppression: Interlock sensors located in ductwork or in hydronic system sensors with corresponding system statuses (such as fans, pumps, etc.) to suppress alarms when system is not operational.

.4 Analog alarms: Program two high-level alarms and two low-level alarms for each analog point. First alarm level to set operational limit and second alarm level to indicate measurement is out of range.

.5 Critical alarms: Program the following critical alarms when status is available.

.1 Equipment status does not match command (unauthorized on/off).

.2 Freeze risk.

.3 High and low pressure.

.4 Equipment fault status.

.5 Abnormal conditions (temperature, pressure, level).

.6 Maintenance alarms: Program the following alarms when status is available.

.1 Equipment alarm or trouble status.

.2 Equipment maintenance alarm.

.3 Dirty filters; coordinate setpoint values with Division 23.

.4 Equipment runtime limit.

.7 Motor Control:

.1 Equipment runtimes:

.1 Totalized and displayed on system graphical user interface.

.2 When runtime data is used for generating maintenance alarms or managing equipment rotation sequences, implement a separate logical point to reset the runtime to zero once it reaches a defined value.

.2 Rotation sequence selector for lead/lag and duty/standby operation:

.2 Program a selector switch on the graphical user interface to enable user to modify the rotation sequence and to manage equipment runtimes.

.8 Motor Interlocks:

.1 Abnormal “on” condition:

.1 Controller to enable control and execute sequence of operations of equipment if system is manually started (for example, motor starter in “hand” position).

.2 Abnormal “off” condition:

.1 When a controller detects a failed start or unexpected shutdown, system is turned off and locked out, after an adjustable delay, to prevent motor operation without a load (for example, broken drive belt) and to protect equipment.

.2 On lockout, the controller to immediately send a signal to control system loops to set field devices back to their shutdown state.

.3 Incorporate a manual reset button on the graphical user interface to restart the system and permit lockout function in or out of service.

.3 Programs and direct digital control (DDC) type controls to not override any safety interlocks.

.9 Starting After a Power Failure:

.1 Once power is restored, electro-mechanical equipment to restart in accordance with a predefined sequence to avoid power overload and control peak demand. Provide programmable start-up delay for each piece of equipment controlled.

.2 Systems equipped with low-power motors may be grouped under the control of a unique delay command. Total power (kW) to be the same and not exceed a maximum value for any group.

3.2 ADVANCED SEQUENCES OF OPERATION

.1 Provide refinements to sequences of operation described in this section to incorporate programming requirements described in ASHRAE Guideline 36.

.2 Energy Management Sequences:

.1 Implement the following energy management sequences when programming the sequences of operation described in this section.

.2 Optimized start routines:

.1 Used to start air handling systems before the defined occupancy schedule to pre-heat or pre-cool the related space in anticipation of occupancy. Start times are determined by the centralized building management system (BMS) to bring space temperatures to setpoint on schedule.

.2 Pre-heat start: Air-handling systems bring space temperatures to their occupied setpoint with their mixing dampers in "full recirculation" position.

.3 Pre-cool start: Air-handling systems bring space temperatures to their occupied setpoint with their mixing dampers in "full recirculation" position. When outdoor conditions are favourable (temperature or enthalpy-based conditions), air-handling systems use free-cooling to perform pre-cool sequence.

.3 Supply air temperature reset:

.1 Provide a supply air temperature reset strategy for designated air-handling systems.

.2 Supply air temperature setpoints: Reset based on criteria specific to each system and application. Confirm setpoint reset schedules and setpoint limits for each system designated to use this strategy.

.3 Supply air temperature reset strategy to use one of the following control stratagems:

.1 For single-zone systems:

.1 Reset the supply air temperature setpoint based on space temperature or the average space temperature when multiple space temperature sensors are deployed to cover a large open space.

.2 In the absence of space temperature sensors, reset the supply air temperature setpoint based on the return air temperature.

.2 For multi-zone systems:

.1 Reset the supply air temperature setpoint to satisfy the zone with the highest demand for cooling as determined by terminal unit damper positions and terminal unit reheat status.

.4 Supply air static pressure reset:

.1 Provide a supply air static pressure reset strategy for designated air-handling systems to optimize supply fan operation in accordance with ASHRAE/IES 90.1.

.2 Requirements:

.1 Connect supply air static pressure signal directly to the controller providing control of the air-handling system to ensure adequate control loop response time.

.2 Provide a proportional–integral–derivative (PID) loop to control the supply fan speed based on the static pressure setpoint.

.3 Reset the supply air static pressure setpoint using the output of a direct-acting PID loop to a setpoint range.

.4 The supply air static pressure setpoint modulates within a specified range by polling the damper positions of terminal units located downstream and ensuring that the terminal units with the highest demand have damper positions between 85% and 95% open (adjustable).

.2 Adjust the acceleration setting, deceleration setting, minimum fan speed, and supply air static pressure setpoint range (high and low) during start-up to achieve stable control system performance.

3.3 SEQUENCES OF OPERATION FOR PLUMBING HYDRONIC (HEATING AND COOLING) VENTILATION LIGHTING SYSTEMS

.1 BMS control panel is in mechanical room.

.2 Storage rooms, Unit heaters UH- 4,5,6,7:

.1 Unit heaters will be controlled by wall mounted -T-stats, line voltage, rating to suit unit heater, lock cover, set point locking device, concealed adjustment, plastic cover and guard, energy star certified. Line voltage thermostat to turn on/off unit heater fan. Line voltage t-stat to be located on an interior wall.

.2 Each room with a unit heater shall have a temperature transmitter located on an interior wall wired to BMS. The control valves for each unit heater will be low voltage and receive a signal from the BMS based on the room temperature transmitter. If room temperature drops 1.5°C (adjustable) below the set point, the two-way control valves will be open, heating water will be supplied to the unit heaters, until the room temperature reaches to its set point 18°C(adjustable).

.3 Corridor area

.1 Forced flow heaters FF -1 (ceiling mounted) and FF-2 (floor mounted) are serving corridor space. Temperature is controlled by wall mounted line voltage T-stat. Line voltage thermostat to turn on/off unit heater fan.

.2 Each room with a unit heater shall have a temperature transmitter located on an interior wall wired to BMS. The control valves for each unit heater will be low voltage and receive a signal from the BMS based on the room temperature transmitter. If the space temperature drops 1.5°C(adjustable) below the set point, the two-way control valves will be open, the fan will be running till the space temperature reaches the set point.

.4 Communication room

.1 In summertime: Cooling will be supplied by the split AC package. Room temperature will be controlled by wall mounted T-stat. Room temperature cooling setpoint for communication room is 26°C (adjustable).

.2 In wintertime: Duct mounted heating coil HC-2 is added to the AC supply air duct. If room temperature is lower than 16.5°C(adjustable), the two-way control valve on the heating coil HC-2 will be activated to heat the room until the room temperature reaches to the set point 18°C(adjustable).

.5 Electrical room

.1 During shoulder season, if the room temperature is = or >29°C(adjustable), the motorized damper in the supply duct will be open, supply fan SF-1 will be turned on, outdoor air will be supplied to the electrical room and will be relieved from the room, until the room temperature reaches to the set point 27.5°C(adjustable).

.2 In Summertime, Split AC is in the electrical room, room temperatures will be controlled by wall mounted T-stats. Room temperature cooling setpoint for electrical room is 28°C (adjustable).

.3 In wintertime: Duct mounted heating coil HC-1 is added to the AC supply air duct. If room temperature is lower than 16.5°C(adjustable), the two-way control valve on the heating coil will be activated to heat the room until reaches to the set point 18°C(adjustable).

.6 Car wash equipment room

.1 Split AC is in the room. Room temperature will be controlled by wall mounted T-stats. Room temperature cooling setpoint for car wash equipment room is 29°C (adjustable).

.2 Unit heater is to provide heating to the room, if room temperature is lower than 16.5°C(adjustable), the two-way control valves on the unit heater will be activated to heat the room until it reaches to the set point 18°C(adjustable).

.3 ERV-2 in this room will provide constant treated outdoor air to this room and exhaust to outside in wintertime, it will be untreated outdoor air in summertime. The ERV will be operated on 24/7.

.7 Wash bay 12,13,14,15:

.1 In-slab heating and infrared heaters are in the rooms. Room temperature will be controlled by the wall mounted t-stats, if the in-slab heating can't provide enough heat, the infrared heater will be started.

.2 MUA- 1 & EF-1, MUA- &EF-2, MUA-3 &EF-3, MUA-4 &EF-4 are interlocked.

.3 Unoccupied mode: if CO/NO2 concentration lower than 25ppm (CO)/0.7ppm (NO2), RH< 60%(adjustable), T-stat will control the room temperature. Ventilation system will be off.

.4 Occupied mode: When the wash bay entrance door opens, the air curtain on the door will be on, the MUA and the EF for this bay will run at lower speed, and the ceiling fan will be turned on, When the car wash process is completed, the exit door opens, the exist air curtain is on, MUA &EF will be running 10 more mins(adjustable). If CO/NO2, RH levels are in an unacceptable range, the MUA&EF will keep working at high speed until CO/NO2, RH levels drop to 30ppm (CO)/ 0.5ppm (NO2), RH65(adjustable). If CO/NO2 level reaches the alarm 50ppm (CO)/1.0 PPM (CO2), both entrance and exit overhead doors open to have enough ventilation, until CO/NO2 level drop to safe range.

.8 Wash bay 12,13,14,15:

.1 In-slab heating and infrared heaters are in the rooms. Room temperature will be controlled by the wall mounted t-stats, if the in-slab heating can't provide enough heat, the infrared heater will be started.

.2 MUA- 1 & EF-1, MUA- &EF-2, MUA-3 &EF-3, MUA-4 &EF-4 are interlocked.

.3 Unoccupied mode: if CO/NO2 concentration lower than 25ppm (CO)/0.7ppm (NO2), RH< 60%(adjustable), T-stat will control the room temperature. Ventilation system will be off.

.4 Occupied mode: When the wash bay entrance door opens, the air curtain on the door will be on, the MUA and the EF for this bay will run at lower speed, and the ceiling fan will be turned on, When the car wash process is completed, the exit door opens, the exist air curtain is on, MUA &EF will be running 10 more mins(adjustable). If CO/NO2, RH levels are in an unacceptable range, the MUA&EF will keep working at high speed until CO/NO2, RH levels drop to 50ppm (CO)/ 1.0 ppm (NO2), RH65(adjustable). If CO/NO2 level reaches the alarm 100ppm (CO)/1.5 PPM (CO2), both entrance and exit overhead doors fully open to have enough ventilation, until CO/NO2 level drop to safe range.

.9 Driveway for 4 wash bays -snow melting system.

.1 Boiler B-3 is dedicated to the snow melting system. Manifold 1,2,3,4 will be serving each driveway area. The temperature sensors will be in the driveway to detect falling or blowing precipitation before snow or ice begin to form, allowing the control to begin managing the system. A snow melt system panel will be in the mechanical room.

.10 In-slab heating system B-4

.1 Boiler B-4 is dedicated for the 4 wash bays in-slab heating system with 50% glycol. Recirculation pumps P-3, P-4, P-5, P-6 will be serving the wash bay 11,12,13,14 individually. The temperature sensors will be in each bay to control room temperature.

.2 The controls contractor to provide a full controls solution to integrate the in-floor heating system with the BMS. Controls contractor to coordinate with the floor heating vendor after award.

.11 General heating B-1 &B-2.

.1 Boiler 1& B-2, recirculation pump P-1, P-2 and P-7 will be serving general heating with 50% glycol. The heating water will serve unit heaters, baseboard heaters, duct mounted heating coils, ERV pre-heat, after-heat coils and forced flow heaters. Boiler control refer to manufacturer's O&M manual and specification boiler section.

.2 Pumps P-1, P-2 and P-7 are in a 50% duty, 50% duty and 50% standby arrangement. Pumps P-1, P-2 and P-7 are ECM motors and speed controlled with a 0-10V signal. Minimum flow should be 20% speed of one pump.

.12 General ventilation ERV-1

.1 ERV-1 is in mechanical room, will provide general ventilation for the storage rooms, corridor, electrical room, communication room, washroom, and janitor room. The unit will run 24/7. The unit will supply 20°C in wintertime, 25°C in summertime.

.13 Mechanical room heating and ventilation.

.1 UH -1, UH-2, and UH-8 ~~EF-5~~ will be controlled by a wall mounted line voltage T-stat to provide heating ~~and cooling~~ for the room. ~~In wintertime unit heaters will provide heating.~~ Line voltage thermostat to turn on/off unit heater fan. Line voltage t-stat to be located on an interior wall. Heating setpoint for the mechanical room is 18°C (adjustable).

.2 Mechanical room shall have a temperature transmitter located on an interior wall wired to BMS. The control valves for each unit heater will be low voltage and receive a signal from the BMS based on the room temperature transmitter. When the room temperature drops 1.5°C below heating setpoint (adjustable), two-way control valve will open, ~~fan starts~~ till the room temperature reaches the set point.

~~.3 During shoulder season and summertime, if the room temperature higher than the set point 1.5°C(adjustable), the motorized damper on the outdoor air intake will be open, EF-5 starts, until the room temperature drops to its set point.~~

.4 Ventilation is provided by ERV-1.

.14 Mechanical room cooling and combustion air.

.1 SF-2 serves two functions. It provides cooling to the mechanical room through air exchange (no mechanical cooling). It also preheats some (not 100%) of the combustion air during colder weather.

.2 Function 1 will be operational when the OAT is above -5°C. When the Mechanical Room temperature exceeds 26°C, turn on the SF and modulate OA and RA dampers to provide a mixed air temperature of 13°C. Supply Fan to de-energize when the Mechanical Room temperature reduces to 24°C.

.3 Function 2 will be operational when the OAT is below -5°C, turn on the SF and modulate the OA and RA dampers to provide 15% OA and modulate the heating control valve to the preheat coil HC-3 to provide a supply air temperature of 19C. Supply Fan to De-energize when the OAT is warmer than -4°C.

3.4 ADJUSTING

.1 Modify sequences of operation to improve system stability and equipment protection, as requested by the representative of consultant.

END OF SECTION