Part 1 GENERAL

1.1 GENERAL

.1 All drawings and all sections of the specifications shall apply to and form an integral part of this section. Refer to the section on Boilers to obtain information on their own packaged controls.

.2 Wherever words "shall be capable of" appear in specifications, interpret as meaning that; where feature or performance referred to is being applied, that feature or performance shall be provided. Where feature or performance is not applied now, but will be applied in future, system shall be provided with all necessary central hardware and software required to support that feature or performance, with only addition of field hardware being required at that future time.

.3 Contractor shall have minimum 5 years experience in related work.

.4 Technical assessment of proposed system will be made as part of our selection criteria.

.5 **The facility has an existing Johnson Controls Metasys system. All new equipment or systems are to be added to the existing system.**

1.2 SCOPE OF SERVICE

.1 The Contractor is to have the expertise to update the existing Metasys system with the new equipment.

.2 Provide fully commissioned heating system controls and documentation. Contractor to provide commissioning sheets for all points on field devices as well as head end equipment.

.3 The Contractor shall provide the necessary engineering, installation, supervision, equipment, commissioning and programming for a complete and fully operational system including but not limited to:

.1 Provide control shop drawings.

.2 Provide a network of Direct Digital Control (DDC) panels (if required).

.3 Provide all wells, sensors, interface devices, automatic control valves, transducers, relays, wiring, conduit raceways and piping.

.4 Provide graphics software, system software, and any third party software required to meet the intent of these specifications.

.5 Provide labelling of the DDC controls system.

.6 Provide labour and supervision for installation, calibration, checkouts and commissioning of systems.

.7 Provide all application, database and graphic programming.

.8 Provide shop drawings, training manuals and as-built drawings.

.9 Provide operator training.

.10 Provide a one-year warranty on all components.

.11 Provide one year of maintenance.

.12 Provide all the necessary software and interface devices for DDC based control of the points listed in the points list and the systems described in the sequences of operation.

.13 Supply all drawings, graphics and sequence of operations in both a hard and soft copy. Drawings and graphics to be able to be read and modified by the City of Winnipeg Staff using Visio software.

1.3 SCOPE OF WORK

.1 Includes the design, supply, installation, commissioning, and training for a complete DDC control system for control and/or monitoring of the following equipment.

1. Boilers B-1 to B-4 and associated injection loop pumps PU-5 and PU-6. Boilers will be controlled by their own vendor controls. Metasys to monitor systems and provide reset temperatures and on/off capability. *
2. Pumps PU-1 to PU-4 complete with variable frequency drives (VFDs) and associated differential pressure controls.*

2. All control valves and devices required by this Section.

3. The Contractor shall be responsible for mounting and wiring all remote-mounted sensors and controls supplied with vendor-supplied equipment.

* Graphic required for this system – see Control Schematics.

1.4 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheets. Include product characteristics, performance criteria, and limitations.

Part 2 Products

2.1 Materials

.1 All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test Site for any new products unless explicitly approved by the Contract Administrator's representative in writing. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

.1 All control products provided for this project shall be compatible with the existing Johnson Controls Metasys system.

.2 The Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the network.

.3 All controllers shall have a communication port for connections with the operator interfaces using the Metasys system.

.4 Communication services over the network shall result in operator interface and value passing that is transparent to the network architecture as follows:

.1 Connection of an operator interface device to any one controller on the network will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the network.

.2 All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the network. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform network value passing.

.3 The time clocks in all controllers shall be automatically synchronized daily via the network. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the network.

.4 The network shall have the following minimum capacity for future expansion:

.1 Each building controller shall have routing capacity for 50 controllers.

.2 The building controller network shall have capacity for 50 building controllers.

.3 The system shall have an overall capacity for 12,500 building controller, custom application controller, and application specific controller input/output objects.

2.3 OPERATOR INTERFACE

.1 Operator Interface. Existing Metasys system is web-based. Through an internet connection, a workstation shall be able to access all information in the system.

.2 System Software

.1 System Graphics. Provide graphics for all systems noted under Section 1.2 of this specification. Graphics shall be similar to existing graphics.

2.4 CONTROLLER SOFTWARE

.1 Furnish the following applications software for building and energy management. All software applications shall reside and operate in the system controllers.

.2 System Security

.1 User access shall be secured using individual security passwords and user names.

.2 Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

.3 User Log On/Log Off attempts shall be recorded.

.4 The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

.3 Scheduling. Provide the capability to schedule each object or group of objects in the system. Each schedule shall consist of the following:

.1 Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. Each schedule may consist of up to 10 events. When a group of objects are scheduled together, provide the capability to adjust the start and stop times for each member.

.2 Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

.3 Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

.4 System Coordination. Provide a standard application for the proper coordination of equipment. This application shall provide the operator with a method of grouping together equipment based on function and location. This group may then be used for scheduling and other applications.

.5 Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

.6 Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

.7 Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the system head-end based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.

.8 Remote Communication. The system shall have the ability to dial out in the event of an alarm using Metasys.

.9 Maintenance Management. The system shall monitor equipment status and generate maintenance messages based upon user-designated run-time, starts, and/or calendar date limits.

.10 Sequencing. Provide application software based upon the sequences of operation specified to properly sequence chillers, boilers, and pumps.

.11 PID Control. A PID (proportional-integral-derivative) algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and PID gains shall be user-selectable.

.12 Staggered Start. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user-selectable.

.13 Anti-Short Cycling. All binary output objects shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

.14 On/Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and set point. The algorithm shall be direct-acting or reverse-acting and incorporate an adjustable differential.

.15 Run-Time Totalization. Provide software to totalize run-times for all binary input objects. A high runtime alarm shall be assigned, if required, by the operator.

2.5 BUILDING CONTROLLERS

.1 General. Provide an adequate number of building controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these panels shall meet the following requirements.

.1 The Building Automation System shall be composed of one or more independent, standalone, microprocessor-based building controllers to manage the global strategies described in the System Software section.

.2 The building controller shall have sufficient memory to support its operating system, database, and programming requirements.

.3 Data shall be shared between networked building controllers.

.4 The operating system of the building controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.

.5 Controllers that perform scheduling shall have a real-time clock.

.6 The building controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall

.1 Assume a predetermined failure mode,

.2 Generate an alarm notification.

.7 The Building Controller shall communicate with other devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services.

.2 Communication.

.1 Each building controller shall reside on a Metasys network.

.2 The controller shall provide a service communication port using Metasys for connection to a portable operator's terminal.

.3 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Keypad. A local keypad and display shall be provided. The keypad shall be provided for interrogating and editing data. An optional system security password shall be available to prevent unauthorized use of the keypad and display. If the manufacturer does not provide this keypad and display, provide a portable operator terminal.

.5 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.6 Memory. The building controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

.7 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.6 CUSTOM APPLICATION CONTROLLERS

.1 General. Provide an adequate number of Custom Application Controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these panels shall meet the following requirements.

.1 The custom application controller shall have sufficient memory to support its operating system, database, and programming requirements.

.1 Data shall be shared between networked custom application controllers.

.2 The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.

.3 Controllers that perform scheduling shall have a real-time clock.

.4 The custom application controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall

.1 Assume a predetermined failure mode and

.2 Generate an alarm notification.

.5 The custom application controller shall communicate with other Metasys devices on the network using the Read (Execute and Initiate) and Write (Execute and Initiate) services.

.2 Communication.

.1 Each building controller shall reside on a Metasys network.

.2 The controller shall provide a service communication port using Metasys for connection to a portable operator's terminal.

.3 Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dustproof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.5 Memory. The custom application controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.

.6 Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

2.7 APPLICATION SPECIFIC CONTROLLERS

.1 General. Application specific controllers (ASCs) are microprocessor-based DDC controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. They are not fully user-programmable but are customized for operation within the confines of the equipment they are designed to serve. Application specific controllers shall communicate with other devices on the network using the Read (Execute) service.

.1 Each ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.

.2 Each ASC will contain sufficient I/O capacity to control the target system.

.2 Communication.

.1 The controller shall reside on a Metasys network. Each network of controllers shall be connected to one building controller.

.2 Each controller shall have a compatible connection for a laptop computer or a portable operator's tool. This connection shall be extended to a space temperature sensor port if required.

.3 Environment. The hardware shall be suitable for the anticipated ambient conditions.

.1 Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at minus 40°C to 65°C (-40°F to 150°F).

.2 Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.4 Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

.5 Memory. The application specific controller shall use non-volatile memory and maintain all BIOS and programming information in the event of a power loss.

.6 Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

.7 Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

2.8 INPUT/OUTPUT INTERFACE

.1 Hardwired inputs and outputs may tie into the system through building, custom application, or application specific controllers.

.2 All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

.3 Universal type input/output points shall be designated (in software) as either a binary or analog type point with appropriate properties. Application specific controllers are exempted from this requirement.

.4 Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

.5 Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

.6 Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

.7 Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

.8 Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

.9 System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.9 POWER SUPPLIES AND LINE FILTERING

.1 Control transformers shall be CSA approved. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with CEC requirements. Limit connected loads to 80% of rated capacity.

.2 Provide transient voltage and surge suppression for all controllers either internally or as an external component.

2.10 AUXILIARY CONTROL DEVICES

.1 Electric valve actuators.

.1 The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.

.2 Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing.

.3 Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.

.4 All 24 VAC/VDC actuators shall operate on Class 2 wiring

.5 All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 Nm (60 in.-lb) torque capacity shall have a manual crank for this purpose.

.2 Control valves.

.1 Control valves shall be two-way or three-way type for modulating service as shown.

.2 Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

.1 Water Valves:

.1 Two-way: 150% of total system (pump) head.

.2 Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

.3 Water Valves:

.1 Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

.2 Sizing Criteria:

.1 Two-position service: Line size.

.1 Two-way modulating service: Pressure drop shall be equal to 50% of the pressure difference between supply and return mains, or 5 psi, maximum.

.2 Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.

.3 Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.

.4 Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

.3 Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

.1 Water zone valves—normally open preferred.

.2 Heating coils in air handlers—normally open.

.3 Other applications—as scheduled or as required by sequences of operation.

.3 Binary Temperature Devices

.1 Low-voltage space thermostat shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) set point range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

.2 Line-voltage space thermostat shall be bimetal-actuated, open contact type, or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, CSA approved for electrical rating, concealed setpoint adjustment, 13°C to 30°C (55°F to 85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.

.3 Low-limit thermostats. Low-limit air stream thermostats shall be CSA approved, vapor pressure type, with an element of 6 m (20 ft) minimum length. Element shall respond to the lowest temperature sensed by any 30 cm (1 ft) section. The low-limit thermostat shall be manual reset only.

.4 Temperature sensors.

.1 Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

.2 Duct sensors shall be single point or averaging. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m^2 (10 ft^2) of duct cross section.

.3 Immersion sensors shall be provided with a separable stainless steel well. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. The well must withstand the flow velocities in the pipe.

.4 Space sensors shall be equipped with set point adjustment, override switch, display, and/or communication port.

.5 Provide matched temperature sensors for differential temperature measurement.

.5 Flow switches.

.1 Flow-proving switches shall be either paddle or differential pressure type, as shown.

.2 Paddle type switches (water service only) shall be CSA approved, SPDT snap-acting with pilot duty rating (125 VA minimum) and shall have adjustable sensitivity with NEMA 1 enclosure unless otherwise specified.

.3 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as specified.

.6 Relays.

.1 Control relays shall be CSA approved plug-in type with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

.2 Time delay relays shall be CSA approved solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

.3 Override timers.

.1 Override timers shall be spring-wound line voltage, CSA approved, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

.7 Current switches.

.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

.8 Pressure transducers.

.1 Transducer shall have linear output signal. Zero and span shall be field adjustable.

.2 Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

.3 Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

.4 Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Overrange limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

.9 Differential pressure type switches (air or water service) shall be CSA approved, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

.10 Pressure-Electric (PE) Switches.

.1 Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale setpoint range of 14-125 kPa (2-18 psig) minimum, CSA approved.

.2 Provide one- or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.

.3 Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.

.4 Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

.11 Local control panels.

.1 All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.

.2 Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be CSA approved for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

.3 Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.11 WIRING AND RACEWAYS

.1 General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16.

.2 All insulated wire to be copper conductors, UL labelled for 90°C minimum service.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 General

.1 The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Contract Administrator for resolution before rough-in work is started.

.2 The Contractor shall inspect the Site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Contract Administrator for resolution before rough-in work is started.

.3 The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor’s work and the plans and the work of others the Contractor shall report these discrepancies to the Contract Administrator and shall obtain written instructions for any changes necessary to accommodate the Contractor’s work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the Contractor to report such discrepancies shall be made by—and at the expense of—the Contractor.

.4 All items shall be installed in accordance with manufacturer’s instructions. All conduit shall be independently supported from the structure in an approved manner.

.5 The control equipment and connecting conduit and wire shall be installed in a neat and workmanlike manner by personnel skilled in this type of installation. All tubing, conduit and plenum rated cable shall be run in an approved manner; conduit shall be

run parallel to or at right angles to the building structure. All conduit, tubing, and plenum cable shall be concealed in all finished spaces. Conduit containing wire or non-metallic tubing may be installed exposed in mechanical rooms or areas where other piping is run exposed.

.6 Non-metallic tubing and plenum cable may be used in concealed accessible spaces provided such installation is allowed by local codes.

.7 All electrical work shall be installed by experienced personnel and conform to CEC and all local codes. Where requirements of Division 16 differ from those contained herein, Division 16 section shall take precedence.

3.3 GENERAL WORKMANSHIP

.1 Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

.2 Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

.3 Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

.4 All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.4 WIRING

.1 All control and interlock wiring shall comply with the CEC and local electrical codes and Electrical section of this specification. Where the requirements of this section differ from those in the Electrical section, the requirements of this section shall take precedence.

.2 All CSA Class 1 (line voltage) wiring shall be CSA approved in approved raceway according to CSA and Division 16 requirements.

.3 All low-voltage wiring shall meet CSA Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)

.4 Where CSA Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are CSA approved for the intended application. For example, cables used in ceiling plenums shall be CSA approved specifically for that purpose.

.5 All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage shall be installed in raceway at levels below 3 m (10 ft).

.6 Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

.7 Do not install wiring in raceway containing tubing.

.8 Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and *neatly* tied at 3 m (10 ft) intervals.

.9 Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

.10 All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

.11 All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

.12 Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.

.13 All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

.14 Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

.15 Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendations and CSA requirements, except as noted elsewhere.

.16 Include one pull string in each raceway 2.5 cm (1 in.) or larger.

.17 Use coded conductors throughout with conductors of different colors.

.18 Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

.19 Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

.20 Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

.21 Adhere to this specification's Division 16 requirements where raceway crosses building expansion joints.

.22 Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

.23 The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (asbuilt) wiring diagrams with terminations identified at the job Site.

.24 Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

.25 Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.5 COMMUNICATION WIRING

.1 The Contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

.2 All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

.3 Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

.4 Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

.5 Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

.6 When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

.7 All runs of communication wiring shall be un-spliced length when that length is commercially available.

.8 All communication wiring shall be labelled to indicate origination and destination data.

3.6 INSTALLATION OF SENSORS

.1 Install sensors in accordance with the manufacturer's recommendations.

.2 Mount sensors rigidly and adequately for the environment within which the sensor operates.

.3 Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

.4 All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

.5 All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

.6 Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

3.7 FLOW SWITCH INSTALLATION

.1 Use correct paddle for pipe diameter.

.2 Adjust flow switch in accordance with manufacturer's instructions.

3.8 ACTUATORS

.1 Mount and link control damper actuators according to manufacturer's instructions.

.1 To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

.2 Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

.3 Provide all mounting hardware and linkages for actuator installation.

.2 Electric/Electronic

.1 Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.9 WARNING LABELS

.1 Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N

This equipment is operating under automatic control

and may start or stop at any time without warning.

Switch disconnect to "Off" position before servicing.

.2 Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

.1 Labels shall use white lettering (12-point type or larger) on a red background.

.2 Warning labels shall read as follows:

C A U T I O N

This equipment is fed from more than one

power source with separate disconnects.

Disconnect all power sources before servicing.

3.10 IDENTIFICATION OF HARDWARE AND WIRING

.1 All wiring and cabling, including that within factory fabricated panels, shall be labelled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

.2 All pneumatic tubing shall be labelled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

.3 Permanently label or code each point of field terminal strips to show the instrument or item served.

.4 Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

.5 Identify all other control components with permanent labels. All plug-in components shall be labelled such that removal of the component does not remove the label.

.6 Identify room sensors relating to terminal box or valves with nameplates.

.7 Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

.8 Identifiers shall match record documents.

3.11 CONTROLLERS

.1 Provide a separate controller for each heating system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

.2 Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.

.3 Future use of spare capacity shall require providing the field device, field wiring, point database definition, and custom software. No additional controller boards or point modules shall be required to implement use of these spare points.

3.12 PROGRAMMING

.1 Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.

.2 Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

.3 Software Programming:

.1 Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the Contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation.

.4 Operator Interface

.1 Standard graphics—Provide graphics for all mechanical systems identified. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.

.2 Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.

.3 The Contractor shall provide all the labour necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.

3.13 CONTROL SYSTEM CHECKOUT AND TESTING

.1 Start-up Testing: All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Contract Administrator's representative is notified of the system demonstration.

.1 The Contractor shall furnish all labour and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

.2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

.3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.

.4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

.5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel.

.6 Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.

.7 Alarms and Interlocks:

.1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.

.2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.

.3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

.2 Testing and balancing shall also be performed according to the Testing and Balancing section.

3.14 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

.1 Refer to Section 21 05 01 – Common Work Results For Mechanical for commissioning details and requirements.

3.15 CLEANING

.1 The Contractor shall clean up all debris resulting from his/her activities daily. The Contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

.2 At the completion of work in any area, the Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

.3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.16 TRAINING

.1 Provide training sessions for Contract Administrator's personnel.

.2 Train the designated staff of Contract Administrator's representative and Contract Administrator to enable them to do the following:

.1 Day-to-day Operators:

.1 Proficiently operate the system

.2 Understand system operation, including DDC system control and optimizing routines (algorithms)

.3 Log on and off the system

.4 Access graphics, point reports, and logs

.5 Adjust and change system set points, time schedules, and holiday schedules

.6 Recognize malfunctions of the system by observation of the graphical visual signals

.7 Understand system drawings and Operation and Maintenance manual

.8 Understand the job layout and location of control components

.9 Access data from DDC controllers and ASCs

.3 Provide course outline and materials. The instructor(s) shall provide one copy of training material per student.

.4 The instructor(s) shall be factory-trained instructors experienced in presenting this material.

.5 Provide a follow up training sessions 6 months after the first training session as described above.

3.17 DDC CONTROLS SEQUENCE OF OPERATION (REFER TO MECHANICAL DRAWINGS)

.1 **Space and Ventilation Heating System:**

.1 Boilers B-1 and B-2

.1 Boilers to operate on their own vendor supplied controls. Vendor controls to supplied by same manufacturer to control all aspects of the boiler including gas train, combustion air blower, burner, etc.

.2 Vendor controls to have ability to tie into existing Metasys system using an N2 protocol.

.3 Metasys system shall have the ability to activate/deactivate the boilers. Once the boilers receive a signal to turn "on" from the Metasys, boiler vendor controls take over and control output of the boiler. Metasys shall show equipment status (on/off)

.4 Boilers are to be operated in series with their own injection loops. Boiler B-2 (condensing) shall be the primary boiler and operate on an outdoor reset schedule (schedule programmed by the Contractor). B-1 (non-condensing) shall not operate if B-2 maintains supply water temperature setpoint. If B-2 cannot maintain temperature setpoint, B-1 shall activate and supplement B-2 to maintain temperature setpoint.

.5 Injection loop pumps PU-5 and PU-6 shall be controlled by boiler vendor supplied controls.

.2 Pumps PU-1 and PU-2 (100% backup)

.1 The pumps complete with VFDs shall operate continuously to provide heating to the building (only one pump is required to operate at one time).

.2 VFDs shall control pump speed based differential pressure. Differential pressure setpoint to be determined during commissioning.

.3 **Contractor to fine tune the VFD to eliminate cycling of the VFD. The VFD shall throttle the pump speed slowly so that the system has a chance to self balance before the pump speed is greatly reduced.** Contractor shall allow for multiple Site visits to ensure heating system is finely tuned and operates according to building schedules.

.4 VFD to duty cycle pumps on a weekly basis.

.5 VFDs to tie into Metasys system. Metasys system shall have capability to turn pump on/off and view pump run status and pump speed. All pump or VFD faults shall be transmitted back to the Metasys system.

.2 **Pool Water and Domestic Hot Water Heating System:**

.1 Boilers B-3 and B-4

.1 Boilers to operate on their own vendor supplied controls. Vendor controls to supplied by same manufacturer to control all aspects of the boiler including gas train, combustion air blower, burner, etc.

.2 Vendor controls to have ability to tie into existing Metasys system using an N2 protocol.

.3 Metasys system shall have the ability to activate/deactivate the boilers. Once the boilers receive a signal to turn "on" from the Metasys, boiler vendor controls take over and control output of the boiler. Metasys shall show equipment status (on/off)

.4 Boilers are to be operated in parallel. Boiler controls to ramp the two boilers up or down as a single boiler plant to optimize efficiencies.

.2 Pumps PU-3 and PU-4 (100% backup)

.1 The pumps complete with VFDs shall operate continuously to provide heating to the pool water and domestic water systems (only one pump is required to operate at one time).

.2 VFDs shall control pump speed based differential pressure. Differential pressure setpoint to be determined during commissioning.

.3 **Contractor to fine tune the VFD to eliminate cycling of the VFD. The VFD shall throttle the pump speed slowly so that the system has a chance to self balance before the speed is greatly reduced.** Contractor shall allow for multiple Site visits to ensure heating system is finely tuned and operates according to building schedules.

.4 VFD to duty cycle pumps on a weekly basis.

.5 VFDs to tie into Metasys system. Metasys system shall have capability to view pump run status and pump speed. All pump or VFD faults shall be transmitted back to the Metasys system.

.3 Two-way Modulating Control Valves:

.1 Each control valve is to communicate directly with the Metasys system. System setpoints are to be controlled by the main operator of the Metasys system.

3.18 ALARMS AND MONITORING

.1 Alarms shall be generated on the DDC system for the following events:

.1 Boiler failure for every boiler

.2 Pump failures for every pump (critical)

3.19 THERMOSTATS AND TEMPERATURE SENSORS

.1 Provide temperature sensors suitable for specified operation.

END OF SECTION