Bidding and Contract Documents, Instructions to Bidders

Tender Form

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1 GENERAL

1.1 GENERAL

1.1.1 Section 20 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Provide a Building Automation System (BAS) utilizing Distributed Digital Control (DDC) to serve new mechanical and associated systems as described on the drawings and in this specification.

1.2.2 Provide all labour, materials, Products, equipment, and services to supply, install, and commission the electronic control and monitoring system with electronic actuation as specified in Specification Division 25 – Integrated Automation.

1.2.3 Provide all computer hardware and software, operator input/output communication devices, communication units, a communication interface to digital system controllers, field sensors, and controls as required to meet the specified performance.

1.2.4 Provide all labour, including calibration, commissioning, software programming and data base generation, generation of colour graphics and additional work necessary to provide a complete and fully operating system.

1.2.5 Provide all necessary wiring for fully complete and functional control system as specified in the Contract Documents.

1.2.6 Building Automation System shall meet the City of Toronto Standard Building Automation System (BAS) Owner requirements outlined in Appendix A. Appendix A shall supersede other requirements outlined in Division 25 where applicable.

1.3 GENERAL SYSTEM REQUIREMENTS

1.3.1 Provide a single architecture common data base microprocessor based electronic control and monitoring BAS system for air handling equipment, heating and cooling and other specified systems employing distributed processing and direct digital control (DDC) with electronic sensing and electronic actuation to conform with the specification requirements. The BAS shall consist of the following:

1.3.1.1 Stand-Alone DDC Controllers

1.3.1.2 Application Specific Controllers

1.3.1.3 Personal computer operator workstation

1.3.2 The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, Application Specific Controllers, and operator devices.

1.3.3 The BAS shall be designed and implemented entirely for use and operation on the Internet and the Owner's Intranet. This functionality for operational access shall extend down to the field panel and field point level.

1.3.4 The primary Controls Application Nodes (AN) shall be fully IT compatible nodes operating over the industry standard IT infrastructure provided for the Project. The Subcontractor responsible for the work of Division 25 (BAS Contractor) shall coordinate with the IT infrastructure support staff or Subcontractors to ensure compatibility and performance of the operation of the BAS over the LAN/WAN made available for its shared use. If the Owner's LAN/WAN is not made available at time of commissioning, this Division shall supply an independent network cabling system for this Division's communication.

1.3.5 The Controls Systems Tier 1 network shall be configured on IT industry standard off-the-shelf technologies compatible with other building systems and Project network arrangements.

1.3.6 All aspects of the Controls Systems Operator Interface shall be provided to operate through an IT industry standard Web Browsers such as Internet Explorer, Firefox, Chrome or Opera.

1.3.7 The Web Browser based Operator Interface provided shall incorporate complete tool sets, operational information displays, multi-Window displays and other interactive aids to assist interpretation and ease of use. Simple HTML based web page displays are not acceptable.

1.3.8 The Web Browser based Operator Interface provided shall not require the procurement or licensing of any special or proprietary software from the BAS Contractor or its suppliers for the Controls Systems OWS.

1.3.9 As required for the functional operation of the Controls Systems, the BAS Contractor shall provide all necessary digital processor

programmable Server(s). These Server(s) shall be utilized for Controls Systems Application configuration, for archiving, reporting and trending of data, for Operator transaction archiving and reporting, for network information management, for alarm annunciation, for Operator Interface tasks, for Controls Application management and the like. These Server(s) shall utilize IT industry standard data base platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE) or approved equal.

1.3.10 Provide a fully distributed processing, on-line, real-time, direct digital control Controls Systems Application in compliance with all applicable codes and as approved by the Authorities Having Jurisdiction (AHJ) at the Site. All communication between Controls Application Nodes shall be digital only.

1.3.11 All Controls Systems Application facilities and features shall be accessible via Enterprise Intranet and Internet Browser with user ID or Password access control for user access.

1.3.12 The Controls Systems Application shall support auto-dial/auto-answer communications to allow Controls Systems Nodes to communicate with other remote Controls Systems Nodes via standard telephone lines. The lines shall be provided by the Owner at the Owner's cost.

1.3.13 The Controls Systems Application network shall utilize an open architecture capable of each and all of the following:

1.3.13.1 Utilizing standard Ethernet communications and operate at a minimum speed of 100 Mb/sec.

1.3.13.2 Connecting via BACnet at the Tier 1 level in accordance with ANSI/ASHRAE Standard 135-2001.

1.3.13.3 Connecting via LonMark as per ANSI/EIA 709 (LonWorks) to LonMark FTT-10 transceivers at the Tier 2 level.

1.3.13.4 Connecting via manufacturer specific Protocol at the Tier 2 level. (i.e. Johnson Controls N2).

1.3.14 Downloading and Uploading

1.3.14.1 Provide the capability to generate and modify the Controls Systems Application software-based sequences, database elements, associated operational definition information, and user-required revisions to same at any designated Workstation together

with the means to download same to the associated Controls Systems Application Node.

1.3.14.2 The Controls Systems Application software tool provided for the generation of custom and database definitions shall be resident in both the Controls Systems Application Node and Controls Systems Application Server(s).

1.3.14.3 Provide the capability to upload Controls Systems Application operating software information, database items, sequences, and alarms to designated Server(s).

1.3.14.4 The functions of this Part shall be governed by the codes, approvals, and regulations applying to this Controls Systems Application as provided.

1.3.15 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

1.3.16 DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central processing device. DDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

1.3.17 Provide English language operator interface using readily understood English language abbreviations and mnemonics.

1.3.18 Future buildings must have the ability to communicate to this building using the BACNet Protocol. The successful Controls Contractor shall provide a PICS (Protocol Implementation Conformance Statement) for the BACNet Gateway. (Minimum conformance of Class 4). The intent is to ensure that existing and future buildings using alternate manufacturers will be able to integrate to this building.

1.4 <u>SYSTEM PERFORMANCE</u>

1.4.1 The system shall conform to the following:

1.4.1.1 Graphic Display. The system shall be dashboard based, and also capable of displaying a graphic with 20 dynamic points/objects with all current data within 10 seconds.

1.4.1.2 Graphic Refresh. The system shall update a graphic with 20 dynamic points/objects with all current data within 8 seconds.

1.4.1.3 Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 2 seconds. Analog objects should start to adjust within 2 seconds.

1.4.1.4 Object Scan. All changes of state and change of analog values will be transmitted over the high-speed Ethernet network such that any data used or displayed at a controller or workstation will have been current within the previous 2 seconds.

1.4.1.5 Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.

1.4.1.6 Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 1 second. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

1.4.1.7 Performance. Programmable controllers shall be able to execute DDC PID control loops at a frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

1.4.1.8 Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other.

1.4.1.9 Reporting Accuracy. The system shall report all values with an end-to-end accuracy as listed or better than those listed in the below table.

Measured Variable	**Reported Accuracy**
Space Temperature	±0.5ºC [±1ºF]
Ducted Air	±0.5ºC [±1ºF
Outside Air	±1.0ºC [±2ºF]
Dewpoint	±1.5ºC [±3ºF]
Water Temperature	±0.5ºC [±1ºF]
Delta-T	±0.15ºC[±0.25ºF]

Measured Variable	**Reported Accuracy**
Relative Humidity	±5% RH
Water Flow	±5% of full scale
Airflow (terminal)	±10% of full scale *(see Note*
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air Pressure (space)	±3 Pa [±0.01 "W.G.]
Water Pressure	±2% of full scale *(see Note*
Electrical (A, V, W, Power factor)	5% of reading *(see Note 3)*
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm
Note 1: 10%-100% of scale	
Note 2: For both absolute and differential	
Note 3: Not including utility-supplied meters	

1.4.1.10 Energy Reporting. The operating software shall have as standard, dashboard widgets which can be selected by the operator to create individual interface points as well as multi-trend graphics as standard.

1.4.1.11 Stability of Control. Control loops shall maintain measured variable at setpoint within the tolerances listed in the below table.

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±50 Pa [±0.2" w.g.] ±3 Pa [±0.01" w.g.]	0-1.5 kPa [0-6" w.g.] -25 to 25 Pa [-0.1 to 0.1" w.g.]
Airflow	±10% of full scale	
Temperature	±0.5ºC [±1.0ºF]	
Humidity	±5% RH	
Fluid Pressure	±10 kPa [±1.5 psi]	0-1 kPa [1-150 psi]
Pressure Differential	±250 Pa [±1.0" w.g.]	0-12.5 kPa [0-50"w.g.]

1.5 <u>COMMUNICATION</u>

1.5.1 All control products provided for this project shall comprise a BACnet internetwork. Communication involving control components (i.e., all types of controllers and Operator Workstations) shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

1.5.2 Each BACnet device shall operate on the BACnet Data Link/Physical layer protocol specified for that device as defined in this Section.

1.5.3 The Contractor shall provide all communication media, connectors, repeaters, bridges, hubs, switches, and routers necessary for the internetwork.

1.5.4 All controllers shall have a communication port for connections with the Operator Workstations using the BACnet Data Link/ Physical layer protocol.

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

1.5.6 Connection of an Operator Workstation device to any one controller on the internetwork 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 internetwork.

1.5.7 All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. 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 internetwork value passing.

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

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

1.5.9.1 Each Building Controller shall have routing capacity for 99 controllers.

1.5.9.2 The Building Controller network shall have capacity for 1000 Building Controllers.

1.5.9.3 The system shall have an overall capacity for 12,500 Building Controller, Advanced Application Controller, and Application Specific Controller input/output objects.

1.6 QUALITY ASSURANCE

1.6.1 All labour, material, equipment and software not specifically referred to herein or on the plans, but are required to meet the functional intent, shall be provided without additional cost to the Owner.

1.6.2 Materials and equipment shall be the catalogue products of a single manufacturer regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements. Products referenced under this Section establish the minimum acceptable standards of the Product features, quality, and performance.

1.6.3 The BAS Contractors shall be manufacturers or licensed factory representatives and installers of the manufacturers, specified for the local area in which the Site is located.

1.6.4 The installing Subcontractor shall have an established working relationship with the Control System Manufacturer.

1.6.5 The installing Subcontractor shall have successfully completed Control System Manufacturer's classes on the control system. The installing Subcontractor shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.

1.6.6 All products used in this installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Consultant in writing. Spare parts shall be available for at least 5 years after completion of this Contract.

1.6.7 The BAS Contractor shall have single source responsibility for the

complete installation and proper operation of the DDC control system and BAS, including debugging and proper calibration of each component in the entire system.

1.6.8 During the initial design the Owner will supply the BAS Contractor a range of BACnet addresses the BAS will run on. The BAS network will run either BACnet over IP or BACnet over MSTP. All BAS points will be network visible so that other BACnet systems can auto discover them. The Contractor shall consult with the Owner during the development of addresses.

1.6.9 The BAS shall be compatible with future control Products for 10 years or more.

1.6.10 Include all software, associated licensing, upgrades, and labour/materials for two (2) years from the date of the Total Performance of the Work.

1.7 REFERENCE STANDARDS

1.7.1 All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, provincial, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and Specifications.

1.7.2 Provide electrical and electronic equipment which is CSA approved where such approval is required by the regulatory authorities.

1.7.3 Provide ASCII American Standard for Communication and Information Interchange code input/output devices with standard EIA Electronic Industry Association interface.

1.8 SUBMITTALS

1.8.1 The Contractor shall provide shop drawings or other submittals on all hardware, software, and installation to be provided. No work may begin on any segment of this project until submittals have been reviewed and approved for conformity with the design intent. All drawings shall be done in DXF or pdf format and provided on magnetic/optical disk and as full-size drawings. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal

requirements. Submittals shall include:

1.8.1.1 A complete bill of materials of equipment to be used shall be listed indicating quantity, manufacturer, model number, and other relevant technical data.

1.8.1.2 Manufacturer's description and technical data, such as performance curves, product specification sheets, and installation/maintenance instructions for each system component.

1.8.1.3 Wiring diagrams and layouts for each control panel. Show all termination numbers.

1.8.1.4 A schematic diagram for all control wiring, communication wiring and power wiring shall be provided. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers, function and data link protocol(s). Show all interface wiring to the control system.

1.8.1.5 Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware on the BAS graphics as it relates to the equipment being controlled.

1.8.1.6 Provide detailed riser diagrams of wiring between central control unit, operator workstation(s), routers, gateways and all control panels.

1.8.1.7 Examples of the color graphic dashboard screens shall be provided. Provide 3 screen shots from 5 existing projects representing various systems. For each screen, provide a conceptual layout of pictures and data, and show or explain which other screens can be directly accessed.

1.8.1.8 A schematic diagram of each controlled system. The schematics shall have all control points/objects labeled and with point/object names shown or listed. The schematics shall graphically show the location of all control elements in the system.

1.8.1.9 A complete control points list.

1.8.1.10 An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.

1.8.1.11 A complete description of the operation of the control system,

including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.

1.8.1.12 A point/object list for each system controller including inputs and outputs (I/O), point/object number, the controlled device associated with the I/O point/object, and the location of the I/O device. Software flag points/objects, alarm points/objects, etc.

1.8.1.13 A BACnet Protocol Implementation Conformance Statement (PICS) for each type of controller and Operator Workstation included in the submittal. PICS shall include for each Product, as a minimum, a list of BACnet functional groups supported, BACnet services supported, BACnet data link options available and BACnet objects provided.

1.8.1.14 Point-to-point verification check sheets once completed.

1.8.2 Upon completion of the Work, provide a complete set of 'as-built' drawings, application software and layout colour graphics on compact disc. Drawings shall be provided as AutoCAD™ compatible files. Two complete sets of hard copies are also to be provided to the Owner.

1.9 <u>OWNERSHIP OF PROPRIETARY MATERIAL</u>

1.9.1 All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:

1.9.1.1 Project graphic images

1.9.1.2 Record drawings

1.9.1.3 Project database

1.9.1.4 Project-specific application programming code

1.9.1.5 All documentation

2 **PRODUCTS**

Not used.

3 **EXECUTION**

3.1 <u>BAS DEMONSTRATION</u>

3.1.1 All BAS Demonstration shall take place on the main Control

Systems Server and WAN. Schedule to add system to main Control Systems Server and WAN with Owner at least two (2) weeks in advance to the demonstration. At the time of request, provide all documentation that the following criterions are met:

3.1.1.1 Updated BAS submittals in electronic and hard copy to the Owner including the updated riser diagram for the system.

3.1.1.2 Reports on verification of Network Layout Verification including but not limited to Building Controller locations, cable routes with length of cable between controllers and any trunk extenders or trunk isolators.

3.1.1.3 Reports on verification of electrical characteristics of BAS network, communications and electrical integrity of Building Controllers.

3.1.1.4 Reports on verification of traffic on BAS Network including but not limited to COVs between Building Controllers, point commands by the operator, point commands by program across the network, alarm reporting on the network, any unresolved points in the system, integrity of the ports on any Building Controller isolator/extender and results of Building Controller tests running at selected baud rate.

3.1.1.5 Demonstrate to the Owner the updates of databases without errors or faults between the temporary Control Systems Server and Building Controllers. If there is no temporary server, demonstrate to Owner after system is added to main Control Systems Server.

3.1.1.6 Reports on verification of system log files, interruption of log files of system traffic and overall acceptable operation of the system where a temporary Control Systems Server is utilized.

3.1.2 Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Owner. Schedule the demonstration with the Owner seven (7) calendar days in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to conform to the Contract Documents, and additional Site visits by the Owner are to be scheduled for re-demonstration, the Contractor shall reimburse the Owner for costs of subsequent Site visits.

3.1.3 The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to instruments, ladders, etc. The Contractor-supplied personnel must be competent with

and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the Site.

3.1.4 Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner.

3.1.5 The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved checklists. Demonstration shall include, but not necessarily be limited to, the following:

3.1.5.1 Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.

3.1.5.2 Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified in the Contract Documents.

3.1.5.3 Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.

3.1.5.4 Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by the Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.

3.1.5.5 Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.

3.1.5.6 Demonstrate that all DDC programs accomplish the specified sequence of operation.

3.1.5.7 Demonstrate that the panels and DDC network of panels automatically recover from power failures within five (5) minutes after power is restored.

3.1.5.8 Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels'

response to LAN communication failures meets the requirements of these Specifications.

3.1.5.9 Identify access to equipment selected by the Owner. Demonstrate that access is sufficient to perform required maintenance.

3.1.5.10 Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.

3.1.6 BAS Demonstration shall be completed and approved prior to the Substantial Performance of the Work.

3.1.7 Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

3.2 <u>BAS ACCEPTANCE PERIOD</u>

3.2.1 After approval of the BAS Demonstration and prior to Total Performance of the Work, Acceptance Period shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, and the like), and TAB report has been submitted and approved. Acceptance Period and its approval will be performed on a system-by-system basis if mutually agreed upon by the Contractor and the Owner.

3.2.2 Operational Test: At the beginning of the Acceptance Period, the system shall operate properly for set period as agreed with the Owner without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these Specifications. At the end of this period, the Contractor shall forward the trend logs to the Owner for review. The Owner shall determine if the system is ready for functional performance testing and document any problems requiring the Contractor's attention.

3.2.2.1 If the systems are not ready for functional performance testing, the Contractor shall correct problems and provide notification to the Owner that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional period.

3.2.2.2 This process shall be repeated until Owner issues notice that the

BAS is ready for functional performance testing.

3.2.3 During the Acceptance Period, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, the Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, the Contractor shall immediately notify the Owner.

3.2.4 Once 5 consecutive days of alarm-free operation are complete and documented, operator training may begin.

3.3 TRAINING

3.3.1 Upon completion of the work and prior to the Substantial Performance of the Work, the Owner's operating and maintenance personnel shall be given complete instructions on the operation and maintenance of the complete system. Include a description of the information flow from field sensors, contacts and devices to the ASCs. Give an overview of the system's communication network to provide a better understanding to the operator of the interplay between initiating devices, field hardware panels, system communications, and their importance within the operating BAS.

3.3.2 An Owner's manual prepared for this project by BAS Contractor shall be used in conjunction with the training. Two copies of the Owner's manual shall be provided.

3.3.3 During system commissioning and at such time as acceptable performance of the BAS hardware and software has been established, the BAS Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall take place during normal working hours and shall be performed by a competent representative of the BAS Contractor, familiar with the BAS software, hardware, and accessories.

3.3.4 The Subcontractor responsible for the work of Division 25 shall give XX hours of instruction to the Owner's designated personnel on the operation of all equipment within the central equipment center and describe its intended use with respect to the programmed functions specified. Operator orientation of the BAS shall include, but not be limited to, the overall operational program, equipment functions (both individually and as part of the total integrated system), commands, system generation, advisories, and appropriate operator intervention required in responding to the

system's operation.

3.4 WARRANTY

3.4.1 Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

3.4.2 All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. If the work specified is split into multiple contracts or a multi-phase contract, then each contract or phase shall have a separate warranty start date and period.

3.4.3 At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Owner, the Owner will sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty.

3.4.4 Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the Contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above mentioned items also can be provided during the warranty period for an additional charge to the Owner by purchasing an in-warranty technical support agreement from the Contractor. Written authorization by the Owner must, however, be granted prior to the installation of any of the above-mentioned items.

3.4.5 The control contractor shall have in place the capability to monitor the operation of the system on a 24-hour basis.

3.4.6 Parts, which have a wear-out characteristic, such as printer ink cartridges, etc., shall not be counted as failures within the terms of this warranty, if they fail or become worn out beyond their stated life expectancy.

3.5 WARRANTY PHASE BAS OPPOSITE SEASON TRENDING AND TESTING

3.5.1 Throughout the warranty phase, trend logs shall be maintained. The Contractor shall forward archive trend logs to the Owner for review upon the Owner's request. The Owner will review these and notify the Contractor of any warranty work required.

3.5.2 Within twelve (12) months of the Substantial Performance of the Work, the Contractor shall schedule and conduct with the Owner an opposite season functional performance testing. The BAS Contractor shall participate in this testing and remedy any deficiencies identified.

3.6 BAS COMMISSIONING

3.6.1 Refer to Section 20 08 00 - Commissioning.

3.7 CONTROL STRATEGIES

3.7.1 Refer to Section 25 90 00 – Sequences of Operation for control sequences and to the associated control schematics on the Drawings for the required number of control loops. Provide all hardware and software necessary to achieve specified control. The sequence of events required for each control loop is described for each system in the control sequence.

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3.3 Installation of Controlled Devices and Sensors
3.4 Identification of Equipment
3.5 Acceptance and Testing Procedures

1 GENERAL

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.1.2 Conform to the requirements of Section 26 00 00 - General Electrical Requirements.

1.2 SCOPE OF WORK

1.2.1 Provide all labour, materials, tools, equipment, training, commissioning and certification required to complete the work as shown on the Drawings and specified in this Section, including:

1.2.1.1 Wiring.

1.2.1.2 Control Valves and Actuators.

1.2.1.3 Control Dampers and Actuators.

1.2.1.4 Control Panels.

1.2.1.5 Sensors.

1.2.1.6 Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).

1.2.1.7 Transducers.

1.2.1.8 Current Switches.

1.2.1.9 Nameplates.

1.2.1.10 Testing Equipment.

1.2.2 Provide the following electrical work as part of the work of this Section, complying with requirements of Division 26 – Electrical and the requirements of this Section.

1.2.2.1 Control wiring between field-installed controls, indicating devices, and unit control panels in this Section, and as specified in other Sections of this Division and under Divisions 20, 21, 22 and 23.

1.2.2.2 Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated

for all mechanical and controls.

1.2.2.3 Wiring associated with annunciator and alarm panels (remote alarm panels) and connections to their associated field devices.

1.2.2.4 Power wiring to field panels and other devices requiring a main supply from circuit breakers provided by Division 26 – Electrical in local emergency power and emergency lighting panels.

1.2.2.5 All other necessary wiring for fully complete and functional control system as specified in the Contract Documents.

1.3 ELECTRICAL WIRING

1.3.1 All wiring shall be in accordance with the latest edition of the Ontario Electrical Safety Code and Division 26 - Electrical. This includes wiring between control components and wiring from such components to electrical circuits of fans, pumps, and any other equipment.

1.3.2 Electrical interlock wiring of field devices (i.e., flow switches, thermostats) associated with equipment specified under other Sections of Division 25 and under Divisions 21, 22 and 23 is the responsibility of this Section, unless indicated otherwise in the Contract Documents.

1.4 CO-ORDINATION OF WORKS

1.4.1 The BAS Contractor shall design, provide, install, test, commission, and guarantee the system.

1.4.2 Provide all control devices, instrumentation, relays, auxiliary contacts, and transformers as specified in the Contract Documents and as required to meet the control and monitoring points and sequence of operation.

1.4.3 Extend control wiring requiring interfacing to systems by Division 26 – Electrical (i.e. fire alarm system, diesel generator control panel, etc.) to respective panel for termination by Division 26 - Electrical.

1.4.4 Dampers

1.4.4.1 Manual balancing dampers, fire dampers, combination fire/smoke dampers and back draft dampers are provided as part of the work of their respective Divisions.

1.4.5 Smoke dampers shall be supplied as part of the work of this Division and installed under Division 23 - HVAC. The BAS Contractor shall provide and connect all associated damper actuators and damper position sensor devices.

1.4.5.1 The BAS Contractor shall supply all remaining automatic control dampers not integral part of equipment specified elsewhere in Division 23. These dampers are to be installed as part of the work of Division 23 – HVAC under the direction of the BAS Contractor who will be fully responsible for the proper operation of the dampers. The BAS Contractor shall provide and connect all associated damper actuators.

1.4.5.2 The BAS Contractor shall provide and connect all damper actuators for dampers specified as an integral part of equipment specified elsewhere in the Contract Documents.

1.4.6 Automatic Control Valves

1.4.6.1 The BAS Contractor shall supply all automatic control valves required by the sequences of operation and not integral part of equipment specified elsewhere in Divisions 22 and 23. These valves are to be installed as part of the work of Division 22 – Plumbing and Division 23 – HVAC, under the direction of the BAS Contractor who will be fully responsible for the proper operation of the valves. The BAS Contractor shall provide and connect all associated valve actuators.

1.4.7 VAV and CAV Controls

1.4.7.1 Supply all actuators, flow transducers, and controllers to VAV/CAV terminal unit manufacturer for installation by the terminal unit manufacturer at the expense of the terminal unit manufacturer. Refer to Section 23 36 00 - Air Terminal Units.

1.4.8 Work by other sections

1.4.8.1 The following equipment is supplied by the BAS Contractor, installed under Division 22 and 23, and connected by the BAS Contractor.

1.4.8.1.1 Air flow measuring stations

1.4.8.1.2 Water pressure sensors

1.4.8.1.3 Water pressure taps, thermal wells, flow switches, flow meters, etc.

that will have wet surfaces, shall be installed under the applicable piping Section under the direction of the BAS Contractor who will be fully responsible for the proper installation and application.

1.4.8.2 Division 26 - Electrical shall provide:

1.4.8.2.1 120-volt AC 15 amp dedicated emergency power circuits for power to the Building Automation System, including all mechanical rooms and control panels.

1.4.8.2.2 Termination at fire alarm system, diesel generator control panel, etc.

1.4.8.3 All other installation work required for the complete installation of the Building Automation System shall be provided by the BAS Contractor.

1.4.8.4 The BAS Contractor shall co-ordinate the control work involving Divisions 20, 21, 22, 23 and 26 - Electrical.

1.5 SUBMITTALS

1.5.1 Provide shop drawings for:

1.5.1.1 Control Valves and Actuators.

1.5.1.2 Control Dampers and Actuators.

1.5.1.3 Control Panels.

1.5.1.4 Sensors.

1.5.1.5 Electric Control Components (Switches, EP Valves, Thermostats, Relays, etc.).

1.5.1.6 Transducers.

1.5.1.7 Current Switches.

1.5.1.8 Testing Equipment.

2 PRODUCTS

2.1 GENERAL

2.1.1 All materials shall meet or exceed all applicable referenced standards, and conform to codes and ordinances of authorities

having jurisdiction.

2.1.2 Provide electronic, pneumatic, and electric control products in sizes and capacities indicated, consisting of valves, dampers, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated in the Contract Documents, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

2.2 INSTRUMENT PIPE AND TUBE

2.2.1 Hydronic and instruments:

2.2.1.1 Connection to main piping: Provide 15mm (½ inch) minimum size threadolet, 15mm x 50mm (½ inch x 2 inch) brass nipple, and 15mm (½ inch) ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.

2.2.1.2 Remote instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with 6mm (¼ inch) FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.

2.2.1.3 Line mounted instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.

2.2.1.4 Instrument tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. Solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing outside diameter size shall be not less than the larger of 6mm (¼ inch) or the instrument connection size.

2.2.1.5 Rigid piping for line mounted instruments: Schedule 40 threaded brass, with threaded brass fittings.

2.2.2 Low pressure air instrument sensing lines:

2.2.2.1 Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.

2.2.2.2 Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

2.3 WIRING

2.3.1 Communication Wiring:

2.3.1.1 Communication wiring shall be provided in a customized color jacketing material. Material color shall be as submitted and approved by the Owner. In addition, all wiring jackets shall be labeled "BAS" in three (3) foot or fewer intervals along the length of the jacket material. An example is provided below:

Purpose	Function	Color	Label
Building Level	Communication	Orange	BAS Building Level Communication
Floor level	Communication	Blue	BAS Floor Level Communication
Inputs/Outputs	Panel to device	White	BAS Input Output Device Cable
24VAC	Control power	White/Black tracer	BAS 24 VAC Control Power

2.3.1.2 The BAS Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC's, ASC's and local and remote peripherals (e.g., operator workstations, printers, and modems).

2.3.1.3 Local Supervisory LAN: For any portions of this network required under this Section of the Specification, the BAS Contractor shall use multimode fiber (62.5 micron) or Category 5E cable per TIA/EIA 68 (10BaseT). Network shall be run with no splices and separate from any wiring over 30V.

2.3.1.4 Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturer's recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over 30V. Shield shall be terminated and wiring shall be grounded as recommended by building controller manufacturer.

2.3.2 Signal Wiring:

2.3.2.1 Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gage wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above 30V.

2.3.2.2 Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

2.3.3 Low Voltage Analog Output Wiring:

2.3.3.1 Low voltage control wiring shall be minimum 18-gage, twisted pair, 100% shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above 30V.

2.3.4 Control Panels:

2.3.4.1 Provide control panels with suitable brackets for wall mounting, unless noted otherwise, for each control system. Locate panel adjacent to systems served. Mount center of control panels 1,524mm (60 inches) above finished floor or roof.

2.3.4.2 Interior mount: Fabricate panels of 0.0625mm (16-gauge) furniture-grade steel, totally enclosed on four sides, with removable perforated backplane, hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.

2.3.4.3 Exterior mount: 0.0625mm (16-gauge) 304 or 316 stainless steel NEMA 4X enclosure. Panel shall have hinged door, keyed lock, and integral, thermostatically controlled heater. Provide hinged deadfront inside panel when flush-mounted control and/or indicating devices are included in panel. Fiberglass or aluminum, as applicable, to be used when gases that are being used in the panel area are corrosive to stainless steel.

2.3.4.4 Provide UL-listed cabinets for use with line voltage devices.

2.3.4.5 Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip.

2.3.4.6 All gauges and control components shall be identified by means of nameplates.

2.3.4.7 All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.

2.3.4.8 Provide a 150mm x 150mm (6” x 6”) minimum wireway (metal wiring/tubing) trough across the entire width of the panel mounted to the top of the panel with close nipples of sufficient size for additional 50% wiring and tubing capacity. Wireways shall not be less than 610mm (24”) in length. Control panel wiring shall be installed and distributed in the wireway to minimize routing of wiring and tubing within the control panel. Wireway construction to be the same as the associated control panel.

2.3.4.9 Complete wiring and tubing termination drawings shall be mounted in, and a second set mounted adjacent to, each panel in a frame with Lexan cover of sufficient size to be easily readable.

2.4 AUTOMATIC CONTROL DAMPERS

2.4.1 Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service. Control dampers used for smoke dampers shall comply with UL 555S. Control dampers used for fire dampers shall comply with UL 555.

2.4.2 Supply control dampers with a leakage rate of less than 15 L/s / m^2 (3 cfm/sq. ft.) at 249 Pa (1" w.g.) static pressure difference.

2.4.3 Use opposed blade type dampers for modulating service. Dampers for two position service, face and bypass and mixing may be parallel blade type.

2.4.4 Construct aluminum airfoil blades of minimum 2.0mm (12-gauge) extruded aluminum. Blades to be 150mm (6") wide single air foil design.

2.4.5 Construct damper frames of extruded aluminum channel with grooved inserts for vinyl seals. Standard frames are 50mm x

100mm x 15mm (2" x 4" x 5/8") on linkage side, and 25mm x 100mm x 25mm (1" x 4" x 1") on the other sides.

2.4.6 Provide 22mm (7/8") hexagon extruded aluminum pivot rods that interlock into the blade section. Bearings to be double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into frame so that the outer bearing cannot rotate.

2.4.7 Design the bearing to prevent metal-to-metal or metal-to-bearing riding surfaces. Interconnecting linkage shall have a separate Celcon bearing to eliminate friction in linkage.

2.4.8 Blade linkage hardware is to be installed in a frame out of the air stream. All hardware to be made of non-corrosive reinforced material or cadmium plated steel.

2.4.9 Supply overlapping damper seals that minimize air leakage.

2.4.10 Insulate all dampers in direct contact with outside air with 22mm (7/8") thick polyurethane foam. Blade construction must provide a 100% thermal break. Insulate frame with polystyrene.

2.4.11 Maximum allowable damper blade length is 1016mm (40") per section.

2.4.12 Provide dampers greater than two sections wide with a jackshaft.

2.4.13 Acceptable dampers are: T. A. MORRISON (TAMCO) 1000 / 9000 and RUSKIN CD-50 / CD-2000.

2.5 <u>STANDARD SERVICE CONTROL VALVES</u>

2.5.1 Control valve sizing and selection is the responsibility of the BAS Contractor. Provide a valve schedule that lists the requirements of the valves for Cv, close off, temperature, etc. This should be a result of analyzing the valves performance across the range of control.

2.5.2 Valves to be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated in the Contract Documents.

2.5.3 Control valves shall be equipped with heavy-duty actuators, selected to proper close-off rating for each individual application.

2.5.4 Minimum close-off rating shall be considered at dead head rating

of the pump.

2.5.5 The control valve assembly shall be provided and delivered from a single manufacturer as a complete assembly.

2.5.6 Characterized Control Valves

2.5.6.1 50mm (2") and smaller: nickel-plated forged brass body rated at 2,758 kPa (400 psi), stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc. 20mm (¾") and smaller for terminal units: nickel plated forged brass body rated at 4,137 kPa (600 psi), chrome plated brass ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-Ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL flow characterizing disc.

2.5.6.2 65mm (2-1/2") through 80mm (3"): GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.

2.5.7 Plug-Type Globe Pattern for Water Service:

2.5.7.1 Where not specifically indicated in the Contract Documents, modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping or size using a pressure differential of 6.9 kPa (1 psi).

2.5.7.2 Single Seated (Two-way) Valves: Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on 'top-and-bottom' guided plugs.

2.5.7.3 Double Seated (Three-way) Valves: Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on 'top-and-bottom' guided plugs.

2.5.7.4 Two- and Three-Way Modulating: twice the load pressure drop, but not more than 34.5 kPa (5 psig).

2.5.7.5 50mm (2”) and smaller: ANSI Class 250 bronze body, stainless steel stem, brass plug, bronze seat, and a TFE packing.

2.5.7.6 65mm (2-1/2”) and larger: ANSI Class 125 or 250 as applicable, cast iron body, stainless steel stem, bronze plug, bronze seat, and a TFE V-ring packing.

2.5.7.7 Two- and three-way globe valves shall be used only if characterized control valves do not fit the sizing criteria or application.

2.5.8 Plug-Type Globe Pattern for Steam Service:

2.5.8.1 Two-Position: line size or sized using 10% of inlet gauge pressure.

2.5.8.2 Modulating: 103 kPa (15 psig) or less: inlet steam pressure, the pressure drop shall be 80% of inlet gauge pressure. Higher than 103 kPa (15 psig) inlet steam pressure: the pressure drop shall be 42% of the inlet absolute pressure.

2.5.8.3 Characteristics: Modified equal-percentage characteristics. Cage-type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.

2.5.8.4 50mm (2”) and smaller: ANSI Class 250 bronze body; stainless steel seat, stem and plug; and a TFE packing.

2.5.8.5 65mm (2-1/2”) and larger: ANSI Class 125 or 250 as applicable, cast iron body, stainless steel seat, stem and plug, and a TFE V-ring packing.

2.5.9 Ball Type:

2.5.9.1 Brass or bronze body; one-, two-, or three-piece design; threaded ends; reinforced Teflon seat; stainless steel ball; standard or ‘V’ style port; stainless steel stem, blow-out proof design, extended to match thickness of insulation.

2.5.9.2 Rating: Cold service pressure 4,138 kPa (600 psi) WOG; Steam working pressure 1,034 kPa (150 psi).

2.5.10 Segmented or Characterized Ball Type:

2.5.10.1 Carbon steel (ASTM 216) body, one-piece design with wafer style ends; reinforced teflon (PTFE) seat; stainless steel ASTM A351 ball; segmented design port with equal-percentage characteristic; stainless steel stem.

2.5.10.2 Rating: Cold service pressure 1,380 kPa (200 psi) WOG

2.5.11 Pressure Independent Control Valves

2.5.11.1 50mm (2") dia and smaller: forged brass body rated at no less than 2,758 kPa (400 psi), chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc.

2.5.11.2 65mm (2-1/2") through 150mm (6') dia: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.

2.5.11.3 Accuracy: The control valves shall accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 34.5 kPa (5 psi) to 345 kPa (50 psi) differential across the valve with a valve body accuracy of +/- 5% variance due to differential pressure fluctuation or +/- 10% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.

2.5.11.4 Flow Characteristics: Equal percentage characteristics.

2.5.11.5 All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable. Actuators for 3-wire floating (tri-state) and for two-position 15mm (½") to 25mm (1") pressure independent control valves shall fail in place and have a mechanical device inserted between the valve and the actuator for the adjustment of flow.

2.5.11.6 Coil optimization 65mm (2-1/2") through 150mm (6") shall be accomplished by utilizing a pressure independent control valve assembly; two temperature sensors providing feedback of coil inlet water temperature and coil outlet water temperature; and a flow meter to provide analog flow feedback. Software shall control the valve to avoid the coil differential temperature from falling below a programmed setpoint. Independent trend logs data shall be available by means of BACnet MS/TP trending data to include, but not be limited, to inlet and outlet coil water temperatures, valve position, absolute flow, absolute valve position, absolute power and heating/cooling energy in BTU/hr.

2.5.11.7 The BAS Contractor shall ensure that the manufacturer provides a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

2.5.11.8 The control valve shall require no maintenance and shall not include replaceable cartridges.

2.5.12 Butterfly valves may be provided for two-position service. Where indicated on the Drawings, supply motorized butterfly valves complete with pipe tee of same rating as piping specification. Supply tight shut-off valves equipped with a limit switch for position indication.

2.5.12.1 50mm (2”) to 300mm (12”): valve body shall be full lugged cast iron 1,379 kPa (200 psig) body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. The shaft shall be supported at four locations by RPTFE bushings.

2.5.12.2 350mm (14”) and larger: valve body shall be full lugged cast iron 1,034 kPa (150 psig) body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings.

2.5.12.3 Butterfly valves for medium pressure service: valve body shall be full lugged carbon steel ANSI Class 300 body with a 316 stainless steel disc without a nylon coating, RTFE seat, and be ANSI Class 300 flange standards. Blowout-proof shaft shall be 17-4ph stainless steel and shall be supported at four locations by glass-backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 50mm (2”) insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.

2.5.13 The BAS Contractor shall ensure that the manufacturer warrants all components for a period of 5 years from the date of production, with the first two years unconditional.

2.5.14 Cavitation Trim:

2.5.14.1 Provide cavitation trim where indicated and/or required, designed

to eliminate cavitation and noise while maintaining an equal percentage characteristic. Trim shall be a series of plates with orifices to break the pressure drop into multi-stages.

2.6 CRITICAL SERVICE CONTROL VALVES

2.6.1 Control valve sizing and selection is the responsibility of the BAS Contractor. Provide a valve schedule that lists the requirements of the valves for Cv, close off, temperature, etc. This should be a result of analyzing the valves performance across the range of control.

2.6.2 General:

2.6.2.1 Provide selection of valve type or body material as determined by installation requirements and pressure class, based on maximum pressure and temperature in piping system.

2.6.2.2 Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve.

2.6.2.3 Control valves shall be equipped with heavy-duty actuators and pilot positioners with proper close-off rating and capability for each individual application.

2.6.2.4 Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

2.7 ENERGY VALVES

2.7.1 Pressure Independent Control Valves with flow and temperature measurements. Based on Belimo.

2.7.1.1 50mm (2”) dia and smaller: forged brass body rated at no less than 2,758 kPa (400 psi), chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc.

2.7.1.2 65mm (2-1/2”) through 150mm (6’) dia: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.

2.7.1.3 Accuracy: The control valves shall accurately control the flow from 0 to 100% full rated flow with an operating pressure differential

range of 34.5 kPa (5 psi) to 345 kPa (50 psi) differential across the valve with a valve body accuracy of +/- 5% variance due to differential pressure fluctuation or +/- 10% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.

2.7.1.4 Flow Characteristics: Equal percentage characteristics.

2.7.1.5 All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable. Actuators for 3-wire floating (tri-state) and for two-position 15mm (½") to 150mm (6") pressure independent control valves shall fail in place and have a mechanical device inserted between the valve and the actuator for the adjustment of flow.

2.7.1.6 Coil optimization 15mm (1/2") through 150mm (6") shall be accomplished by utilizing a pressure independent control valve assembly; two temperature sensors providing feedback of coil inlet water temperature and coil outlet water temperature; and a flow meter to provide analog flow feedback.

2.7.1.7 Software shall control the valve to avoid the coil differential temperature from falling below a programmed setpoint. Independent trend logs data shall be available by means of BACnet MS/TP trending data to include, but not be limited, to inlet and outlet coil water temperatures, valve position, absolute flow, absolute valve position, absolute power and heating/cooling energy in BTU/hr.

2.7.1.8 The BAS Contractor shall ensure that the manufacturer provides a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) and the Testing Adjusting Balancing Bureau (TABB).

2.7.2 The control valve shall require no maintenance and shall not include replaceable cartridges.

2.8 VALVE AND DAMPER ACTUATORS

2.8.1 Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.

2.8.2 Provide electric actuators of the enclosed reversible gear drive type that can accept modulating control signals as required. Actuators using balance relays or mechanical travel limiting switches are not acceptable.

2.8.3 Electric damper actuators shall be spring return on outdoor air service.

2.8.4 Valves installed for outdoor service applications must be provided with actuators that operate satisfactorily at -30°C (-22°F) through 50°C (122°F).

2.8.5 Coupling shall be V-bolt dual nut clamp with a V-shaped, toothed cradle.

2.8.6 Mounting: actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.

2.8.7 Fail-Safe Operation: mechanical, spring-return mechanism

2.8.8 Actuators to be overload protected electronically throughout rotation and come with electronic fail safe actuator for pressure independent valves 50mm (2-1/2") through 150mm (6").

2.8.9 Proportional actuators shall be fully programmable through an EEPROM without the use of actuator mounted switches.

2.8.10 Housing: minimum requirement NEMA type 2 / IP54 mounted in any orientation.

2.9 <u>POSITIONERS</u>

2.9.1 Positive positioning relays shall be provided on damper motors and valves when required to provide sufficient power, sequencing, repeatability, or speed of response. Positioner shall allow field adjustment of both starting pressure and operating span. Positioner shall provide an antilock feature and shall provide accurate positioning without excessive air bleed.

2.10 <u>SMOKE DAMPERS</u>

2.10.1 Provide Ruskin SD-35, Class I smoke dampers where indicated on the Drawings.

2.10.2 Provide parallel blade type dampers, suitable for horizontal or vertical mounting. Provide multiple dampers where sizes exceed code limitations.

2.10.3 Select dampers with airflow resistance not exceeding 13 Pa (0.05" w.g.) at design flow rates.

2.11 SMOKE DAMPER MOTORS

2.11.1 Size for torque required for damper seal at load conditions with one actuator per damper section. Mechanically paralleled or 'piggybacked' actuators are not permitted.

2.11.2 Coupling shall be V-bolt dual nut clamp with a V-shaped toothed cradle. Aluminum clamps or set screws are not acceptable.

2.11.3 Overload protection: microprocessor or an electronic based motor controller providing burnout protection if stalled before full rotation is reached. The actuator shall be electronically cut off at full open to eliminate noise generation with the holding noise level to be inaudible.

2.11.4 Actuator timing shall be per OBC and NFPA requirements.

2.11.5 Temperature rating: actuator shall have a UL555S listing by the damper manufacturer for 177°C (350°F).

2.11.6 Proportional smoke and fire damper actuators shall meet all requirements specified above and shall modulate 0-100% open in response to a 2-10vdc or 4-20mA control signal. A 2-10vdc feedback output shall provide a 2-10vdc signal for position indication.

2.11.7 Balancing smoke and fire damper actuators shall meet all requirements specified above and shall include an integral adjustable maximum opening potentiometer for airflow adjustment.

2.11.8 A manual override winder and locking mechanism shall be provided for override operation of the actuator on a loss of power to the actuator.

2.11.9 Actuator to include auxiliary switches for signaling, fan control, or position indication.

2.11.10 Housing for combination fire/smoke damper actuator to be steel, aluminum is not acceptable.

2.12 GENERAL FIELD DEVICES

2.12.1 Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal

conditioning for all field devices as recommended by field device manufacturers and as required for proper operation in the system.

2.12.2 BAS Contractor shall assure that all field devices are compatible with controller hardware and software.

2.12.3 Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, is not designed to work with 'two-wire' type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the BAS Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

2.12.4 For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, the BAS Contractor shall provide proper devices, including 120V power as required. Such devices shall have accuracy and repeatability equal to, or better than, the accuracy and repeatability listed for respective field devices.

2.12.5 Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.13 <u>ELECTRONIC TEMPERATURE SENSORS</u>

2.13.1 Supply factory calibrated temperature sensors that utilize 1000-Ohm nickel wire or platinum (RTDs).

2.13.2 Temperature sensors utilized for measuring duct temperatures shall incorporate an averaging style temperature element (RTD) of sufficient length to ensure a proper average of the variation across the full cross section of the duct.

2.13.3 Temperature sensors utilized for measurement of fluid temperatures shall incorporate a separate well of a material suitable for the service.

2.13.3.1 Water service – brass

2.13.3.2 Steam service - 304 SS

2.13.3.3 Ethylene/propylene glycol service - 304 SS

2.13.4 Temperature sensors utilized for wall mounting in occupied spaces

and connected to ASCs used for terminal unit control must be complete with a momentary contact switch for override initiation, concealed temperature setpoint adjustment and telephone style jack for connection of a portable service terminal.

2.13.5 Supply sensors with the following accuracy:

2.13.5.1 Duct and water insertion sensors +/- 0.5% at 20°C (68°F)

2.13.5.2 Duct averaging sensors +/- 1.0% at 20°C (68°F)

2.13.5.3 Space sensors +/- 0.5% at 20°C (68°F)

2.14 ELECTRONIC HUMIDITY SENSORS

2.14.1 Provide humidity sensors with a solid state sensing element suitable for operating ranges of 10 to 100% RH and an accuracy of +/- 3% over a range of 5 to 95% RH.

2.14.2 Incorporate in the humidity sensors a transducing circuit for conversion of the sensed variable to a voltage level for digital conversion.

2.15 PRESSURE SENSORS

2.15.1 Provide pressure transmitters suitable for continuous contact with the material being measured (i.e., air, water, glycol, or steam as applicable).

2.15.2 Pressure transmitters shall have a linear output of 0-5V. Pressure transmitters shall have a span of not greater than twice the static pressure at maximum flow or differential pressure at shut-off as applicable.

2.16 AIRFLOW MONITORING STATIONS

2.16.1 Airflow measuring stations must be designed and built to comply with, and provide results in accordance with accepted practice as defined for system testing in the ASHRAE Handbook of Fundamentals, as well as the Industrial Ventilation Handbook.

2.16.2 Where required, incorporate air straightening to ensure an accurate flow profile.

2.16.3 Utilize total pressure and static pressure probes and incorporate averaging manifolds, internal piping, and connections for an external differential pressure/flow transmitter. Hot wire

anemometer technology is also acceptable

2.16.4 Airflow stations incorporated into the flow channels of silencers must be a series of probes inserted and tubed together according to design criteria, to provide an acceptable airflow profile.

2.16.5 Connect air flow monitoring devices supplied as part of equipment such as air terminal units to the BAS as required based on the Sequences of Operation set out in Section 25 90 00.

2.17 PRESSURE SWITCHES

2.17.1 Supply pressure-sensing elements of the bourdon tube, bellows, or diaphragm type, with adjustable setpoint and differential.

2.17.2 Pressure switches to be snap action type rated at 120 Volts, 15 Amps AC or 24 Volts DC.

2.18 TEMPERATURE SWITCHES

2.18.1 Temperature sensing element shall be liquid, vapour, or bimetallic type.

2.18.2 Supply adjustable setpoint and differential.

2.18.3 Snap action type rated at 120 volts, 15 Amps, or 24 volts DC as required.

2.18.4 Sensors shall operate automatically and reset automatically. Temperature switches shall be of the following types:

2.18.4.1 Room Type suitable for wall mounting on standard electrical box with or without protective guard.

2.18.4.2 General Purpose Duct Type suitable for insertion into air ducts, insertion length of 450mm (18 inches).

2.18.4.3 Thermowell Type complete with compression fitting for 20mm (¾") NPT well mounting of length of 100 mm (4 inches). Immersion wells shall be stainless steel.

2.18.4.4 Strap-on-Type complete with helical screw stainless steel clamps.

2.19 PRESSURE ELECTRIC SWITCHES

2.19.1 Provide pressure electric switches with diaphragm operated S.P.D.T. snap acting contacts with electrical rating suitable for

application.

2.19.2 Pressure electric switches must withstand up to 172 kPa (25 psig) and be provided with adjustable cut-in and cut-out settings between 21 and 138 kPa (3 and 20 psig).

2.20 CURRENT SENSING RELAYS

2.20.1 Supply current sensing relays in fan and pump motor starters to detect flow a required in the sequence of operation.

2.20.2 Supply current sensing relays complete with metering transformer ranged to match load being metered.

2.20.3 Provide adjustable latch level, a minimum differential of 10% of latch setting between latch level and release level, and an LED for local status indication.

2.20.4 Ensure relay contacts are compatible with control circuit voltage.

2.21 CARBON DIOXIDE SENSORS

2.21.1 Supply carbon dioxide sensors for air quality control purposes with the following characteristics:

2.21.1.1 Measurement Range – 0-2000 ppm CO_2

2.21.1.2 Accuracy +/- 100 ppm

2.21.1.3 Repeatability +/- 20 ppm

2.21.1.4 Drift +/- 100 ppm per year

2.21.1.5 Output Signal 0-10 VDC proportional over the 0-2000 ppm range

2.21.1.6 Response time 20 seconds maximum

2.21.1.7 Operating conditions 0-50°C (32-122°F), 10-100% RH non-condensing

2.21.2 Provide one single point calibration kit

2.22 LOW TEMPERATURE LIMIT THERMOSTATS

2.22.1 Where shown on the Drawings or described in the sequences of operation, install low temperature limit thermostats complete with 6.1m (20'-0") of sensing capillary sensitive to 400mm (16") and

manual reset. Provide one limit thermostat for approximately every 6 sq. m (65 sq. ft.) of duct area.

2.23 HIGH TEMPERATURE LIMIT THERMOSTATS

2.23.1 Where shown on the Drawings or described in the Sequences of Operation in this Section below for individual systems, provide high limit thermostats to shut down respective fan system(s).

2.23.2 Provide a single rod and tube type manual reset limit thermostat set at 57.5°C (135°F).

2.24 WATER FLOW SWITCHES

2.24.1 Supply paddle actuated water flow switches with snap acting S.P.D.T. contacts rated at 16 Amps 120/1/60 AC full load.

2.25 AIR PROVING SWITCHES

2.25.1 Air proving and motor status shall be performed by an adjustable latch level current switch. Upon motor current rise above setpoint, switch shall activate and status shall be proven.

2.26 DAMPER STATUS SWITCHES

2.26.1 Damper status switches shall be lever operated, activated by damper blade movement, and mounted securely on damper frame.

2.26.2 Damper switch shall have contact rating of 5 Amperes at 120V AC and be C.S.A. approved.

2.27 OCCUPANCY SENSORS

2.27.1 Provide passive infrared sensors, which shall operate on 24 VDC, with a current draw of 26 mA. Sensors shall be sealed and gasketed and be moisture and dust proof. The passive infrared sensor shall utilize a temperature compensated dual element sensor and a multi-element Fresnel lens.

2.27.2 Provide isolated relay with normally open, normally closed, and common outputs for use with HVAC control.

2.28 CONTROL RELAYS

2.28.1 Supply and install load relays capable of switching 10 Amps at 120/1/60.

2.29 CONTROL TRANSFORMERS

2.29.1 Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be ULC and CSA listed. Primary and secondary sides shall have replaceable fuses in accordance with the NEC. Transformer shall be properly sized for application, and mounted in minimum NEMA 1 enclosure.

2.30 TIME DELAY RELAYS (TDR)

2.30.1 TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a NEMA 1 enclosure.

2.30.2 TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.

2.30.3 TDRs shall be ULC and CSA listed, Crouzet type.

2.31 ELECTRIC PUSH BUTTON SWITCH

2.31.1 Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 VAC operation.

2.32 PILOT LIGHT

2.32.1 Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC.

2.33 ALARM HORN

2.33.1 Panel-mounted audible alarm horn shall be continuous tone, 120 VAC Sonalert solid-state electronic signal.

2.34 ELECTRIC SELECTOR SWITCH (ESS)

2.34.1 Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 VAC operation.

2.35 NAMEPLATES

2.35.1 Duct and pipe mounted sensors and panels shall be provided with

minimum size 75mm x 25mm x 3.2mm (3" x 1" x 1/8") lamacoid nameplates, clearly identifying the equipment and functions with letter and number designation. Nameplates shall be mechanically secured and listed in the Operating and Maintenance manual.

2.36 TESTING EQUIPMENT

2.36.1 The BAS Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. The BAS Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/- 0.5% accurate, test equipment shall be +/- 0.25% accurate over same range).

3 EXECUTION

3.1 PREPARATION

3.1.1 Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the BAS Contractor.

3.2 GENERAL REQUIREMENTS

3.2.1 Installation shall meet or exceed all applicable federal, provincial, and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

3.2.2 Install systems and materials in accordance with manufacturer's instructions, roughing-in Drawings and details shown on Drawings. Install electrical components and use electrical products complying with requirements of the Ontario Electrical Safety Code and all local codes.

3.2.3 Install all equipment, accessories, conduits, and interconnecting wiring in a neat manner by skilled and qualified workmen using the latest standard practices of the industry.

3.2.4 Notify the Consultant in writing of any conflict between these specifications and manufacturer's instructions.

3.2.5 Retain, at no additional cost to the owner, original equipment suppliers to provide contacts that are required on the point schedules and in the software and sequences specified. Provide the necessary relays and transformers required to interconnect equipment.

3.2.6 All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor. Anti-vibration mounts shall be provided, if required, for the proper isolation of equipment.

3.2.7 Install equipment to allow for easy maintenance access. Ensure equipment does not interfere in any way with access to adjacent equipment and personal traffic in the surrounding space.

3.2.8 Install equipment in locations providing ventilation and ambient conditions for its specified function.

3.2.9 Install all electrical wiring in conformance with the requirements of the local electrical authority, the Ontario Building Code and, unless otherwise indicated in the Contract Documents, the Specification Sections of Division 26 – Electrical.

3.2.10 Install low voltage wiring in accordance with the control manufacturer's recommendations. Run all wiring in a protective conduit in areas where exposed or where required to meet with applicable codes. Plenum rated (FT6) type cables may be used in accordance with applicable codes, in concealed, accessible locations such as ceiling spaces and wall cavities.

3.2.11 Shield and ground communication trunk wiring at a single end. Do not splice trunk cables.

3.3 <u>INSTALLATION OF CONTROLLED DEVICES AND SENSORS</u>

3.3.1 Supply equipment to be installed under the work of other Divisions in accordance with their work schedule.

3.3.2 Coordinate final location of all sensors with the Consultant's field representative prior to installation.

3.3.3 Sensor assemblies and elements must be readily accessible. Provide access doors as required to allow for easy replacement and servicing.

3.3.4 Support field mounted transmitters and sensors on pipe stands or channel brackets.

3.3.5 Locate all sensing elements to correctly sense measured variable. Isolate elements from vibrations and temperatures, which could affect measurement.

3.3.6 Install temperature sensing elements with thermal paste to ensure accurate reading.

3.3.7 Install averaging type RTDs in serpentine configuration with adequate provision for the mechanical protection of the sensor. Support along its entire length.

3.3.8 Modifications to plenum and ductwork must achieve the intent of the Contract Documents and adhere to the following:

3.3.9 Mount sensors with extension necks such that access to sensors is not restricted by insulation.

3.3.10 Keep cutting to a minimum and perform in a neat and workmanlike manner.

3.3.11 Provide patches and access covers of the same material and thickness as adjoining ductwork. Provide necessary reinforcing and fastening materials.

3.3.12 Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

3.3.13 Provide gaskets, seals, and insulation to restore to, or exceed as found conditions in areas where the BAS Contractor has made modifications.

3.3.14 All damper actuators shall be rigidly mounted and supplied with heavy-duty linkage consisting of a crank arm, pushrod, and swivel ball joint to connect to the damper shaft. Secure linkages in such a manner as to prevent slipping under normal operating torque.

3.3.15 Where the point schedules indicate that auxiliary contact provision, provide all instrumentation, wiring, conduit, power supplies, and services as required to integrate these points into the BAS.

3.3.16 Provide interposing and motor control relays at the local item of equipment or at the associated MCC as applicable. Provide all relays, wiring, conduit, power supplies, and services as required integrating these points into the BAS.

3.3.17 Control Air System:

3.3.17.1 All main air piping between the compressors and the control panels shall be copper, run per ASTM B88

3.3.17.2 Branch Control Air Piping: Accessible tubing is defined as that tubing run in mechanical equipment rooms; inside mechanical equipment enclosures, such as heating and cooling units, instrument panels; across roofs, in pipe chases, etc. Inaccessible tubing is defined as that tubing run in concrete slabs, furred walls, or ceilings with no access.

3.3.17.2.1 Provide copper tubing with maximum unsupported length of 0.91m (3 feet) for accessible tubing run exposed to view. Terminal single-line connections less than 457mm (18 inches) length may be copper tubing, or polyethylene tubing run. Tubing exposed to ambient conditions must be properly protected from sunlight and protected from damage.

3.3.17.2.2 Provide copper tubing for inaccessible tubing, other than in concrete pour. In a concrete pour polyethylene tubing may be used, install in rigid conduit or vinyl-jacketed polyethylene tubing. Install in galvanized rigid steel conduit at all exterior locations. Install in PVC Schedule 40 conduit if encased in concrete.

3.3.17.2.3 Polyethylene tubing may be used in control panels provided it is run in a neat and orderly fashion, bundled where applicable, properly supported and installed in a neat and workman like manner. Fasten flexible connections bridging cabinets and doors, neatly along hinge side, and protect against abrasion.

3.3.17.2.4 Pressure test control air piping at 207 kPa (30 psi) for 24 hours. Test fails if more than 13.8 kPa (2 psi) loss occurs.

3.3.17.2.5 Number-code or color-code tubing, except local individual room control tubing, for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.3.18 Control Wiring:

3.3.18.1 The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connection of electric control devices.

3.3.18.2 Install complete wiring system for electric control systems.

Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Installation of wiring shall generally follow building lines. Install in accordance with the latest edition of the Ontario Electrical Safety Code and Division 26 - Electrical. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

3.3.18.3 Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened.

3.3.18.4 Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over 30V. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.

3.3.18.5 All WAN and LAN communication wiring shield shall be terminated as recommended by controller manufacturer. All WAN and LAN communication wiring shall be labeled with a network number, device ID at each termination and shall correspond with the WAN and LAN system architecture and floor plan submittals.

3.3.18.6 Install all control wiring external to panels in electric metallic tubing or raceway. Installation of wiring shall generally follow building lines. Provide compression type connectors. Install wiring in galvanized rigid steel conduit at all exterior locations and where subjected to moisture. Install in PVC Schedule 40 conduit if encased in concrete. All conduits penetrating partitions, walls or floors shall be sealed with a submitted and approved fire/smoke sealant material to prevent migration of air through the conduit system.

3.3.18.6.1 The BAS Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.

3.3.18.6.2 Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units, instrument panels etc.; in accessible pipe chases with easy access, or suspended ceilings with easy access. Installation of wiring shall generally follow building lines.

3.3.18.6.3 Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties and not to

exceed 1.52m (5 foot) intervals.

3.3.18.6.4 Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on the ceiling or duct.

3.3.18.6.5 Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking.

3.3.18.7 Communication cabling shall be provided in an Owner approved color dedicated to the BAS.

3.3.18.8 Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

3.3.19 Install control valves so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

3.3.20 Averaging temperature sensors shall cover no more than 0.61 sq.m per linear meter (2 sq.ft per linear foot) of sensor length except where indicated. Sensor shall be installed in location where flow is sufficiently homogeneous and adequately mixed. Install averaging sensors in a serpentine configuration with adequate provision for the mechanical protection of the sensor. Support along its entire length.

3.3.21 Install airflow measuring stations per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

3.3.22 Install fluid flow sensors per manufacturer's recommendations in an unobstructed straight length of pipe.

3.3.23 Provide element guard for relative humidity sensors as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

3.3.24 Water differential pressure transmitters shall be installed in a valve bypass arrangement to protect against over pressure damaging the transmitter. Establish required locations and coordinate installation of valve bypass with the respective Subcontractors.

3.3.25 Install steam differential pressure transmitters as shown on the Drawings per manufacturer's instructions.

3.3.26 Install pipe surface mount temperature sensors with thermally conductive paste at pipe contact point. Where sensor is to be installed on an insulated pipe, the BAS Contractor shall neatly cut insulation, install sensor, repair or replace insulation and vapor barrier, and adequately seal vapor barrier.

3.3.27 Where possible, install flow switches in a straight run of pipe at least 15 diameters in length to minimize false indications.

3.3.28 Adjust current switches for motor status monitoring so that setpoint is below minimum operating current and above motor no load current.

3.3.29 Supply Duct Pressure Transmitters:

3.3.29.1 Install pressure tips with at least four (4) 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install static pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.

3.3.29.2 On VAV Systems, locate down-duct transmitter pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system.

3.4 <u>IDENTIFICATION OF EQUIPMENT</u>

3.4.1 Identify each piece of equipment, including sensors, controlled devices, and control panels, with a nameplate identifying the equipment and functions with a letter and number designation.

3.4.2 Nameplates shall be minimum size 75mm x 25mm (3" x 1") and 3.2mm (1/8") thick laminated plastic with black face and white center and 6.4mm (1/4") deep engraved lettering. Nameplates shall be securely attached to the equipment.

3.4.3 Printed nametags are acceptable for cabinet mounted components providing they are securely attached.

3.5 ACCEPTANCE AND TESTING PROCEDURES

3.5.1 The BAS Contractor shall request completion acceptance in writing and advise the Consultant of situations that would prevent a complete testing of overall system performance.

3.5.2 Work and/or systems installed under this Division and under Divisions 21, 22 and 23 shall be fully functioning prior to Demonstration and Acceptance Phase. The BAS Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:

3.5.2.1 Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.

3.5.2.2 Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.

3.5.2.3 Verify integrity/safety of all electrical connections.

3.5.2.4 Coordinate with the Subcontractor responsible for the TAB work to obtain control settings that are determined from balancing procedures. Record the following control settings as obtained from the Subcontractor responsible for the TAB work, and note any TAB deficiencies in the BAS Start-Up Report:

3.5.2.4.1 Optimum duct static pressure setpoints for VAV air handling units.

3.5.2.4.2 Minimum outside air damper settings for air handling units.

3.5.2.4.3 Optimum differential pressure setpoints for variable speed pumping systems.

3.5.2.4.4 Calibration parameters for flow control devices such as VAV terminal units and flow measuring stations.

3.5.2.5 The BAS Contractor shall provide a hand-held device as a minimum to the Subcontractor responsible for the TAB work to facilitate calibration. Connection for any given device shall be local to it (i.e. at the VAV terminal unit or at the thermostat). Hand-held device or portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start-up.

3.5.2.6 Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the

device, using an instrument, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range). Record the measured value and displayed value for each device in the BAS Start-up Report.

3.5.2.7 Check and set zero and span adjustments for all transducers and transmitters.

3.5.2.8 For dampers and valves:

3.5.2.8.1 Check for adequate installation including free travel throughout range and adequate seal.

3.5.2.8.2 Where loops are sequenced, check for proper control without overlap.

3.5.2.9 For actuators:

3.5.2.9.1 Check to insure that device seals tightly when the appropriate signal is applied to the operator.

3.5.2.9.2 Check for appropriate fail position, and that the stroke and range is as required.

3.5.2.9.3 For pneumatic operators, adjust the operator spring compression as required to achieve close-off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split-range positioners to verify proper operation. Record settings for each device in the BAS Pre-Commissioning Report.

3.5.2.9.4 For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.

3.5.2.10 Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the BAS Start-Up Report.

3.5.2.11 For outputs to reset other manufacturer's devices (for example, VSDs) and for feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.

3.5.3 Sensor Checkout and Calibration:

3.5.3.1 Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.1 degrees C (0.2 degrees F) of each other for temperature and within a tolerance equal to 2 percent of the reading of each other for pressure. Tolerances for critical applications may be tighter.

3.5.3.2 Calibrate all sensors using one of the following procedures:

3.5.3.2.1 Sensors without transmitters: Make a reading with a calibrated test instrument within 150mm (6 inches) of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20 percentage of the expected range.

3.5.3.2.2 Sensors with transmitters: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 150mm (6 inches) of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

3.5.3.3 Sensors shall be within the tolerances specified for the device.

3.5.4 Coil Valve Leak Check:

3.5.4.1 Verify proper close-off of the valves. Ensure the valve seats properly seat by simulating the maximum anticipated pressure difference across the circuit. Demonstrate to the Owner the verification of zero flow by measuring the coil differential pressure. If there is pressure differential, close the isolation valves to the coil

to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.5.5 Valve Stroke Setup and Check:

3.5.5.1 For all valve and actuator positions checked, verify the actual position against the Operator Interface readout.

3.5.5.2 Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command the valve to various few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

3.5.6 After completion of installation and in cooperation with Subcontractors responsible for the related work of other Specification Sections, adjust each control device and component to ensure that the operations are in accordance with the Sequences of Operation specified in Section 20 95 00.

END OF SECTION

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3.1 Installation

1 GENERAL

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Provide all labour, materials, tools, equipment, training, commissioning and certification required to complete the work as shown on the Drawings and specified in this Section, including:

1.2.1.1 Operator Workstations.

1.2.1.2 Control System Servers.

1.2.1.3 Portable Operator Terminal / Remote Workstation.

1.2.2 Furnish and install all Operator Interfaces and Control System Servers as required for the BAS functions specified in the Contract Documents. All computers shall be warranted by the manufacturer for a period of one year after final acceptance.

2 PRODUCTS

2.1 GENERAL

2.1.1 All materials shall meet or exceed all applicable referenced standards, and conform to codes and ordinances of authorities having jurisdiction.

2.1.2 The make and model of control system server computers, personal computers (PC), notebook PC's, monitors, and printers shall comply with Owner's current standards for desktop personal computers as of the date of the Substantial Performance of the Work. Contact the Owner for the current computer hardware standards.

2.1.3 Operating system for operator workstation shall comply with the Owner's current standards for desktop personal computers as of the date of the Substantial Performance of the Work. Contact the Owner for the current computer software standards.

2.2 CONTROL SYSTEMS APPLICATION SERVER (CSS)

2.2.1 Provide Controls Systems Application Server to archive historical

data including trends, alarm and event histories and transaction logs.

2.2.2 Server shall be an IBM compatible computer platform. Minimum 2 GB RAM, 19" LCD monitor, and 500 GB hard-drive. DVD Read / Write drive shall be provided for system backup use.

2.2.3 One printer shall be provided for information summaries, custom reports, and graphical printing. The printer shall be capable of six (6) pages per minute at a resolution of 600 dpi, and use inkjet technology.

2.2.4 Equip this Server with the same software tool set that is located in the Primary Controls Systems Application Nodes for system configuration, custom logic definition, and for colour graphic configuration.

2.2.5 Access to all information on the Controls Systems Server shall be through the same Operator Interface functionality used to access individual nodes. When logged onto a Server the Operator will be able to also interact with any of the primary Nodes on the Controls Systems Application.

2.3 <u>OPERATOR WORKSTATION (OWS)</u>

2.3.1 The Operator Interface provided shall include the functionality to selectively combine data and information from any system element or component in the Controls Systems Application on a single Browser window display panel at the Operator's option. This shall include both current information and historical data stored on the Server.

2.3.2 The Controls Systems Application Operator Workstation (OWS) shall operate on Microsoft® Windows 8 or other approved platform, with the same hardware as described under the CSS.

2.3.2.1 The BAS Contractor shall provide a modem for connection to the Owner's paging service.

2.3.3 Operator Workstations shall be placed as indicated on the Drawings or as directed by the Owner.

2.4 <u>PORTABLE OPERATOR TERMINAL (POT) / REMOTE WORKSTATION</u>

2.4.1 Portable Operator Terminal shall support system management by

connection to the controllers and by connection via the Internet while serving as the remote workstation.

2.4.2 Provide one notebook personal computer (PC) that meets or exceeds the minimum requirements of the BAS software and meets or exceeds Owner's minimum requirements. Notebook PC shall contain a DVD-RW Drive.

2.4.3 Provide carrying case and extra battery.

2.4.4 Operating system for operator workstation shall be Microsoft Windows 8 Professional.

2.4.5 Provide additional hardware, video drivers, serial ports, etc., to facilitate all control functions and software requirements specified for the building automation system.

2.4.6 Provide all controller configurations, interface software, and/or plug-ins for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs, etc.

2.4.7 Wherever a POT connection point is not accessible in the same room as the device controlled, Contractor shall provide a wireless system, to permit configuration, testing, and operation.

2.4.8 BAS licensing for this POT shall allow unlimited access to all aspects of the any manufacturer's system including system access, workstations, points, programming, database management, graphics etc.

2.4.9 No restrictions shall be placed on the license.

2.4.10 All operator interfaces, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

2.5 <u>UNINTERRUPTABLE POWER SUPPLY</u>

2.5.1 Provide an uninterruptible power supply system (UPS) providing battery backup for each operator workstation, server and peripheral devices.

2.5.1.1 UPS shall protect against blackouts, brownouts, surges, and noise.

2.5.1.2 UPS shall include LAN port and modem line surge protection.

2.5.1.3 UPS shall be sized for a 7-minute full load runtime, 23-minute ½-load runtime, with a typical runtime of up to 60 minutes. Transfer time shall be 2-4 milliseconds.

2.5.1.4 UPS shall provide a 480 Joule suppression rating and current suppression protection for 36,000 Amps and provide 90 percent recharge capability in two to four hours. Suppression response time shall be instantaneous.

2.5.1.5 UPS low voltage switching shall occur when supply voltage is less than 94 Volts. UPS shall be provided with modem surge suppression and LAN port connections.

3 EXECUTION

3.1 INSTALLATION

3.1.1 Installation shall meet or exceed all applicable federal requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

3.1.2 All installation shall be in accordance with manufacturer's published recommendations.

3.1.3 Set up workstations and printers as indicated on the Drawings. Install all software and verify that the systems are fully operational.

3.1.4 No license, software component, key or any piece of information required for installing, configuring, operating, diagnosing and maintaining the system shall be withheld from the Owner.

3.1.5 Install electronic control system Operation and Maintenance Manuals, programming guides, network configuration tools, and control Shop Drawings etc. on each OWS and CSS. Provide interface or shortcuts to guide user to the appropriate information.

3.1.6 Set up portable operator terminal and configure it as the remote workstation. Install all software and verify that the system is operational.

END OF SECTION

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1 **GENERAL**

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Provide all labour, materials, tools, equipment, training, commissioning and certification required to complete the work as shown on the Drawings and specified in this Section, including:

1.2.1.1 Application Nodes (ANs)

1.2.1.2 Application Specific Controllers (ASCs)

1.2.2 Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.

2 **PRODUCTS**

2.1 GENERAL

2.1.1 All materials shall meet or exceed all applicable referenced standards, federal requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 CONTROLLERS – APPLICATION NODES (AN)

2.2.1 Controls AN shall provide both standalone and networked direct digital control of mechanical and electrical building systems as required by the Specifications. The primary AN shall support a minimum of [2,000] field points together with all associated features, sequences, schedules, applications as required for fully functional distributed processing operations.

2.2.2 A dedicated AN shall be configured and provided for each building.

2.2.3 Each AN shall retain program, control algorithms, and setpoint information for at least 72 hours in the event of a power failure and shall return to normal operation upon stable restoration of normal line power.

2.2.4 Each AN shall monitor and report its communication status to the Controls Systems Application. The Controls Systems shall provide a system advisory upon communication failure and restoration.

2.2.5 Provide a means to prevent unauthorized personnel from accessing setpoint adjustments and equipment control definitions at the AN.

2.2.6 The AN shall provide the functionality to download and upload configuration data, both locally at the AN and via the Controls Application networks.

2.2.7 The AN shall perform the functional monitoring of all Controls Application variables, both from real hardware points, software variables, and controller parameters such as setpoints.

2.2.8 The primary AN shall manage and direct all information traffic on the Tier 1 network, between the Tier 1 and Tier 2 networks and to the Server(s).

2.2.9 All AN on the Tier 1 network shall be equipped with all software and functionality necessary to operate the complete user interface, including graphics, via a Browser connected to the Node on the network or directly via a local port on the AN.

2.2.10 The AN shall be capable of direct connection to multiple field busses using different protocols simultaneously as indicated below. Should the AN not support multiple field busses then install multiple AN in parallel to achieve this functionality.

2.2.10.1 An RS-485 serial field bus such as MSTP or the manufacturer's open field bus.

2.2.10.2 A LON field bus for supervision and control of LON based controllers that conform to the Lon Talk standard.

2.2.11 The AN shall integrate data from both field busses into a common and conformal object structure. Data from both field busses shall appear in common displays throughout the Operator Interface in the same format. Conformal formatting shall be provided for each type of data not dependent on the type of field bus from which the data originated.

2.2.12 The AN shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.

2.2.13 A failure at an AN shall not cause failures or non-normal operation

at any other system AN other than the possible loss of active real-time information from the failed AN.

2.2.14 Ancillary AN equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.

2.2.15 Each AN shall report its communication status to the Application. The Application shall provide a system advisory upon communication failure and restoration.

2.2.16 The AN shall incorporate the ability to download and upload configuration data, both locally at the AN and via the Application communications network.

2.3 APPLICATION SPECIFIC CONTROLLERS (ASCS)

2.3.1 Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each ASC shall operate as a stand-alone controller capable of performing its specified control sequences.

2.3.2 ASCs shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.

2.3.3 ASCs shall have a library of control processes to perform the sequence of operation specified in the "Execution" portion of this specification. Control processes shall include:

2.3.3.1 Two Position Control

2.3.3.2 Proportional, Integral, plus Derivative Control

2.3.3.3 Industry standard VAV terminal box control process

2.3.3.4 Industry standard fan coil control process

2.3.3.5 Industry standard heat pump control process

2.3.3.6 Industry standard AC system control process

2.3.3.7 Industry standard AHU system control process

2.3.4 Each ASC shall have sufficient memory to support its own operating system and databases, including control processes, energy management applications, operator I/O and local alarm

management.

2.3.5 Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

2.3.6 Powerfail Protection

2.3.6.1 All controller setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the ASC.

2.3.6.2 All controller memory containing program configuration and control parameters shall be either non-volatile EEPROM/EPROM memory or shall be provided with battery back-up sufficient to sustain the contents of RAM memory for a minimum of one (1) year. Alternatively, provide 72-hour battery backup for program & data memory.

2.3.7 Configuration and Download

2.3.7.1 The ASCs shall have the capability of receiving configuration and program loading by all of the following:

2.3.7.1.1 Locally, via a direct portable laptop service tool;

2.3.7.1.2 Over the network, from the portable laptop service tool;

2.3.7.1.3 From the Operator Workstation, via the communication networks.

3 **EXECUTION**

3.1 PREPARATION

3.1.1 Examine areas and conditions under which control systems are to be installed. Do not proceed with the Work until unsatisfactory conditions have been corrected in manner acceptable to the BAS Contractor.

3.2 INSTALLATION

3.2.1 Installation shall meet or exceed all applicable federal requirements, referenced standards, and conform to codes and ordinances of authorities having jurisdiction.

3.2.2 All installation shall be in accordance with manufacturer's

published recommendations.

3.2.3 All equipment installed shall be mechanically stable and, as necessary, fixed to wall or floor. Anti-vibration mounts to be provided, if required, for the proper isolation of equipment.

3.2.4 Install equipment to allow for easy maintenance access. Ensure equipment does not interfere in any way with access to adjacent equipment and personal traffic in the surrounding space.

3.2.5 Install equipment in locations providing ventilation and ambient conditions for its specified function.

3.3 CONTROLLER QUALITY AND LOCATION

3.3.1 Digital Control Stations (DCS) are referenced to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple controllers to meet requirements of the Division 25 Specification Sections.

3.3.2 Where a DCS is referenced, the BAS Contractor shall provide at least one (1) controller, and additional controllers as required, in sufficient quantity to meet the requirements of the Division 25 Specification Sections. Restrictions in applying controllers are specified under this Section. The BAS Contractor shall extend power to the DCS from an acceptable power panel. If the BAS supplier wishes to further distribute panels to other locations, the BAS Contractor is responsible for extending power to that location also. Furthermore, the BAS Contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the Project and maintain adequate clearance for maintenance access.

3.3.3 The BAS Contractor shall locate DCS's as referenced in the Contract Documents. It is the BAS Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.

3.3.4 The BAS Contractor shall provide a minimum of the following:

3.3.4.1 One DCS (including at least one controller) in each chilled water/hot water plant mechanical room

3.3.4.2 One DCS (including at least one controller) for each air handler located in applicable mechanical room

3.3.4.3 One DCS (including at least one controller) for each critical fan system

3.3.4.4 One DCS (including at least one controller) for each pumping system

3.3.4.5 One DCS (including at least one controller) for each steam pressure reducing station

3.3.4.6 One controller for each piece of terminal equipment located at the equipment.

3.4 SURGE PROTECTION

3.4.1 The BAS Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS, routers, gateways, and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10 percent above or below measured nominal value, with no effect on hardware, software, communications, and data storage.

3.5 CONTROL POWER SOURCE AND SUPPLY

3.5.1 The BAS Contractor shall extend all power source wiring required for operation of all equipment and devices provided under this Section.

3.5.2 General requirements for obtaining power include the following:

3.5.2.1 In the case where additional power is required, obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 600V source, obtain power from the electrically most proximate 120V source fed from a common origin.

3.5.2.2 Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and is the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or of the correct voltage to supply the controls, provide separate transformer

3.5.2.3 Where a controller controls multiple systems on varying levels of

power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served. Furthermore, the controller in that condition shall monitor each power type served to determine so logic can assess whether a failure is due to a power loss and respond appropriately. A three-phase monitor into a digital input shall suffice as power monitoring.

3.6 IDENTIFICATION OF EQUIPMENT

3.6.1 Identify each piece of equipment, including sensors, controlled devices, and control panels, with a nameplate identifying the equipment and functions with a letter and number designation.

3.6.2 Nameplates shall be minimum size 75mm x 25mm (3" x 1") and 3.2mm (1/8") thick laminated plastic with black face and white center and 6.4mm (1/4") deep engraved lettering. Nameplates shall be securely attached to the equipment.

3.6.3 Printed nametags are acceptable for cabinet mounted components providing they are securely attached.

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1 GENERAL

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Provide all labour, including calibration, commissioning, software programming and data base generation, generation of colour graphics and additional work necessary to provide a complete and fully operating system.

1.3 LICENSING

1.3.1 Provide or upgrade all licensing for all software packages at all required workstations. BAS licensing shall allow unlimited simultaneous users for access to all aspects of the system including system access, workstations, points, programming, database management, graphics etc. No restrictions shall be placed on the licensing. All operator interfaces, programming environment, networking, database management, and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

1.3.2 All software should be available on all Operator Workstations (OWS) provided, and on all Portable Operator Terminals. Hardware and software keys to provide all rights shall be installed on all workstations. At least two (2) sets of compact discs or USB drives shall be provided with backup software for all software provided, so that the Owner may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses.

1.3.3 Provide licensing and original software copies for each OWS.

1.3.4 Provide licensing and original software copies for each remote graphic workstation. Licenses for remote graphic workstations shall allow for access to any Site and shall not be restricted to accessing only the LANs included in this Project.

1.3.5 In the last month of the Warranty Period, upgrade all software and firmware packages to the latest release (version) in effect at the end of the Warranty Period.

2 PRODUCTS

2.1 GENERAL

2.1.1 All materials shall meet or exceed all applicable referenced standards, federal, provincial, and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 OPERATOR INTERFACES

2.2.1 The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colours, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the Operator's Workstation (OWS).

2.2.2 User access shall be protected by a flexible and Owner redefinable software-based password access protection. Password protection shall be multi-level and partitionable to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific Master Password. Provide an audit trail of all user activity on the Controls Systems including all actions and changes.

2.2.3 The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

2.2.3.1 User access for selective information retrieval and control command execution.

2.2.3.2 Monitoring and reporting.

2.2.3.3 Alarm and non-normal condition annunciation.

2.2.3.4 Selective operator override and other control actions.

2.2.3.5 Information archiving, manipulation, formatting, display, and reporting.

2.2.3.6 Controls Systems internal performance supervision and diagnostics.

2.2.3.7 On-line access to user HELP menus.

2.2.3.8 On-line access to current as-built records and documentation. At minimum, one (1) copy of all record documentation shall be stored on a designated OWS or Server and be accessible to the Owner.

2.2.3.9 Means for the controlled re-programming, re-configuration of systems operation and for the manipulation of database information in compliance with the prevailing codes, approvals, and regulations for the component applications and elements.

2.2.3.10 Means to archive all Controls Systems Contract Project specific configuration databases, software programs, and other pertinent operational data such that any component of the software and project specific operational databases may be reloaded on Site from archived data.

2.2.3.11 Provide on-line reports and displays making maximized use of simple English language descriptions and readily understood acronyms, abbreviations, icons and the like to assist user understanding and interpretation. All text naming conventions shall be consistent in their use and application throughout the Controls Systems.

2.3 <u>OPERATOR WORKSTATIONS</u>

2.3.1 The Operator Interface provided shall include the functionality to selectively combine data and information from any system element or component in the Controls Systems Application on a single Browser window display panel at the Operator's option. This shall include both current information and historical data stored on the Server.

2.3.2 Each Controls Systems Application fixed and portable OWS shall be on-line configurable for specific functionalities and associated groups of system points and elements.

2.3.3 Navigation Trees

2.3.3.1 Provide the capability to display multiple navigation trees that aid the operator in navigating throughout all systems and points connected. At minimum, provide a tree that identifies all systems on the Controls Systems networks.

2.3.3.2 Provide the capability for the Operator to add custom trees. The Operator shall be able to define any logical grouping of systems or points and arrange them on the tree in any selected order. Provide the capability to nest groups within other groups. Provide at

minimum for five levels of nesting.

2.3.3.3 The navigation trees shall be "dockable" to other displays in the Operator interface including graphic displays. The trees shall appear as part of the display and may be individually detached and minimized to the Windows task bar or closed. Provide for a single keystroke to reattach the navigation tree to a primary display.

2.3.4 Divisible Display Windows

2.3.4.1 Provide for the operator to divide the display area within a single Browser window into multiple display panels. The content of each display panel can be any of the standard summaries and graphics provided in the Controls Systems Application.

2.3.4.2 Provide each display panel with minimize, maximize, and close icons.

2.3.5 Alarms

2.3.5.1 Alarms shall be routed directly from primary Controls Systems Application Nodes to OWS and Server. Provide for specific alarms from specific points to be routed to selectable OWS and Server. The alarm management portion of the Controls Systems software shall, at minimum, provide the following functions:

2.3.5.2 Log date and time of alarm occurrence.

2.3.5.3 Generate a "Pop-Up" window on the Browser display panel, with audible alarm, informing the Operator that an alarm has been received.

2.3.5.4 Allow an Operator, with the appropriate password, to acknowledge, temporarily silence or cancel an alarm.

2.3.5.5 Provide an audit trail on hard drive for alarms by recording user acknowledgement, deletion, or cancelling of an alarm. The audit trail shall include the ID of the user, the alarm, the action taken on the alarm and a time/date stamp.

2.3.5.6 Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop-up window described herein. Controls Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

2.3.5.7 Provide for any attribute of any object in the Controls Systems to

be designated to report as an alarm.

2.3.5.8 The Controls Systems Application shall annunciate systems diagnostic alarms indicating system failures and non-normal operating conditions.

2.3.5.9 The Controls Systems Application shall annunciate controls alarms at minimum as required by Part 3.

2.3.5.10 Provide the on-line means to display alarms within the Browser windows by date/time of occurrence, priority class, point designation, value, or other defined text keywords.

2.3.6 Operator Transaction Archiving

2.3.6.1 Provide the means to automatically archive all Operator activities on the Controls Systems Application and for the recall of same for reporting.

2.3.6.2 Provide the means to sort and report archived activities by Operator, date/time, activity type and system area.

2.3.6.3 Provide access protection to preclude the unauthorized removal or tampering with archived records.

2.3.6.4 Provide management support facilities for the deletion and re-initializing of archived record logs under Master Password control or equal means.

2.3.7 Reports

2.3.7.1 Reports shall be generated and directed to one or more of the following: User interface displays, printers archived at the Owner's defined option. As a minimum, the Controls Systems Application shall provide the following reports:

- All points in the Controls Systems Application.
- All points in a specific Controls Systems.
- All points in a user-defined group of points.
- All points currently in alarm.
- All points locked out.
- All Controls Systems Application schedules.

• All user defined and adjustable variables, schedules, interlocks, diagnostics, systems status reports, and the like.

2.3.7.2 Provide all applicable original manufacturers standard reports for the Controls Systems.

2.3.8 Dynamic Colour Graphics

2.3.8.1 Provide for any number of real-time colour graphic displays shall be able to be generated and displayed in the Controls Systems Application limited only by memory data storage capacity.

2.3.8.2 Graphics shall be based on Scalar Vector Graphic (SVG) technology.

2.3.8.3 Values of real-time attributes displayed on the graphics shall be dynamic and updated on the displays.

2.3.8.4 The graphic displays shall be able to display and provide animation based on real-time data that is acquired, derived, or entered into the operating Controls Systems.

2.3.8.5 Provide for the Owner to be able to change values (setpoints) and states in system controlled equipment directly from the graphic display.

2.3.8.6 Provide a graphic editing tool that allows for the creation and editing of graphic files. It shall be possible to edit the graphics directly while they are on line, or at an off line location for later downloading to the AN.

2.3.8.7 Provide a complete user expandable symbol library containing all of the basic symbols used to represent components of a typical system. Implementing these symbols in a graphic shall involve dragging and dropping them from the library to the graphic.

2.3.9 Schedules

2.3.9.1 Provide multiple schedule input forms for automatic time-of-day scheduling and override scheduling of operations. At a minimum, the following spreadsheet types shall be accommodated:

• Weekly schedules.

• Temporary override schedules.

• Special “Only Active If Today Is A Holiday” schedules.

• Monthly schedules.

2.3.9.2 Schedules shall be provided for each group, system, and sub-system in the Controls Systems Application. It shall be possible to include all or any commandable points residing within the Controls Systems in any custom schedule. Each point shall have a unique schedule of operation relative to the system use schedule, allowing for sequential starting and control of equipment within the system. Scheduling and rescheduling of points shall be accomplished easily via the system schedule spreadsheets.

2.3.9.3 Multiple monthly calendars for a 12-month period shall be provided that allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

2.3.10 Historical Trending And Data Collection

2.3.10.1 Trend and store point history data for all actual and virtual (software) points and values as required by the Owner.

2.3.10.2 The trend data shall be stored in a manner that allows custom queries and reports using industry-standard software tools.

2.3.10.3 At a minimum, provide the capability to perform statistical functions on the historical database:

• Average.

• Arithmetic mean.

• Maximum/minimum values.

• Range – difference between minimum and maximum values.

• Standard deviation.

• Sum of all values.

• Variance.

2.3.11 Operator Access Security (Combined Password and User ID)

2.3.11.1 Provide for Operator access into the Controls Systems via the use of on-line Owner defined software Password and User Identification (ID) pairs, unique for each Operator and unique throughout the Controls Systems Application, to supplement

standard password access control.

2.3.11.2 Stored password/user ID definitions shall be stored in encrypted formats whether at the Controls Server or at the application node.

2.3.11.3 Password logins shall not be echoed on any screen or printer except during Master Password definition processes. An Operator defining a password shall be required to re-enter to confirm authenticity.

2.3.11.4 Operator access privileges shall be definable in terms of functions and Project areas.

2.3.11.5 As part of the access privileges definition for each user the Owner shall be able to define at minimum the following:

- Access times by day.
- Permanent or temporary, with expiry date, password.
- Number of incorrect access attempts allowed before the password is disabled.
- Whether or not the Operators are able to redefine their own password.
- A field for the Operator's e-mail address.
- A field for the Operator's contact phone number.
- Definition of the Operator's access privilege functionalities including viewing only, full control, selected functions, etc.

2.3.12 Texting/E-mail Notification

2.3.12.1 Provide the means of automatic alphanumeric notification of personnel for Owner defined events.

2.3.12.2 The Controls System shall support both numeric and alphanumeric notification, using Alphanumeric, PET, or IXO Protocol at the Owner's option and/or service by the owners wireless service provider.

2.3.12.3 Users shall have the ability to modify the phone number or message to be displayed on the pager through the Controls System software.

3 EXECUTION

3.1 SYSTEM CONFIGURATION

3.1.1 Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, remote operator workstation, portable operators terminal, printer, and remote communications.

3.2 OPERATOR INTERFACES

3.2.1 Set up workstations and printers as indicated on the Drawings. Install all software and verify that the systems are fully operational.

3.2.2 No license, software component, key or any piece of information required for installing, configuring, operating, diagnosing and maintaining the system shall be withheld from the Owner.

3.2.3 Install electronic control system Operation and Maintenance Manuals, programming guides, network configuration tools, and control Shop Drawings etc. on each OWS and CSS. Provide interface or shortcuts to guide user to the appropriate information.

3.2.4 Set up portable operator terminal and configure it as the remote workstation. Install all software and verify that the system is operational.

3.3 GRAPHIC SCREENS

3.3.1 Floor Plan Screens: The Contract Document Drawings will be made available to the Contractor in AutoCAD format upon request. These Drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these Drawings for the Contractor's purpose. Graphic Screens shall be submitted for approval.

3.3.1.1 Provide graphic floor plan screens for each floor of each building.

3.3.1.1.1 Indicate the location of all equipment that is not located on the equipment room screens.

3.3.1.1.2 Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens.

3.3.1.1.3 Display the space temperature point adjacent to each temperature sensor symbol. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone.

3.3.1.1.4 Mechanical floor plan Drawings will be made available to the Contractor upon request for the purpose of determining zone boundaries. Indicate room numbers as provided by the Owner.

3.3.1.1.5 Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.

3.3.1.2 Provide graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.

3.3.1.3 If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

3.3.1.4 Provide a graphic site plan with links to and from each building plan.

3.3.2 System Schematic Screens: Provide graphic system schematic screen for each HVAC subsystem controlled with each I/O point in the Project appearing on at least one graphic screen. System graphics shall include flow diagrams with status, setpoints, current analog input and output values, operator commands, etc. as applicable. General layout of the system shall be schematically correct. Input/output devices shall be shown in their schematically correct locations. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen.

3.3.2.1 Provide graphic screens for each air handling system. Indicate outside air temperature and enthalpy, and mode of operation as applicable (i.e., occupied, unoccupied, warm-up, cool-down). Link screens for air handlers to the heating system and cooling system

graphics. Link screens for supply and exhaust systems if they are not combined onto one screen.

3.3.2.2 Provide a graphic screen for each zone. Provide links to graphic system schematic screens of air handling units that serve the corresponding zone.

3.3.2.3 Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature. Link screens for chilled water and condenser water systems if they cannot fit onto one cooling plant graphic screen.

3.3.2.4 Provide a heating system graphic screen showing all points associated with the boilers, and pumps. Indicate outside air dry-bulb temperature. Link screens for secondary heating water systems if they cannot fit onto one heating plant graphic screen.

3.3.2.5 Link screens for heating and cooling system graphics to utility history reports showing current and monthly electric uses, demands, peak values, and other pertinent values.

3.3.3 Bar Chart Screens: On each graphic Bar Chart Screen, provide drawing links to the graphic air handling unit schematic screens.

3.3.3.1 Provide a graphic chilled water valve screen showing the analog output signal of all chilled water valves in a bar chart format, with signals expressed as percentage of fully open valve (percentage of full cooling). Indicate the discharge air temperature and setpoint of each air handling unit, cooling system chilled water supply and return temperatures, and the outside air temperature and humidity on this graphic. Provide drawing links between the graphic cooling plant screen and this graphic screen.

3.3.3.2 Provide a graphic heating water valve screen showing the analog output signal of all air handling unit heating water valves in a bar chart format, with signals expressed as percentage of fully open valve (percentage of full heating). Indicate the temperature of the controlled medium (such as AHU discharge air temperature or zone hot water supply temperature) and the associated setpoint and the outside air temperature and humidity. Provide drawing links between the graphic heating plant screen and this graphic screen.

3.3.4 Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the

graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog values that are in a 'high alarm' condition in a red color, 'low alarm' condition in a blue color. Indicate digital values that are in alarm condition in a red color.

END OF SECTION

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3 EXECUTION

3.1 Preparation
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1 **GENERAL**

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Provide all labour, materials, tools, equipment, training, commissioning and certification required to complete the work as shown on the Drawings and specified in this Section, including:

1.2.1.1 Local Supervisory LAN Gateways/Routers.

1.2.2 Provide all interface devices and software to provide an integrated system connecting ANs, ASCs and Gateways to the Owner's Wide Area Network (WAN).

2 **PRODUCTS**

2.1 GENERAL

2.1.1 All materials shall meet or exceed all applicable referenced standards, federal requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 LOCAL SUPERVISORY LAN GATEWAY/ROUTERS

2.2.1 The Supervisory Gateway shall be a microprocessor-based communications device that acts as a gateway/router between the Supervisory LAN CSSs or OWS and the Primary LAN.

2.2.2 The gateway shall perform information translation between the Primary LAN and the Local Supervisory LAN, which is 100 Mbps Ethernet TCP/IP and shall use BACnet over IP.

2.2.3 The gateway shall contain its own microprocessor, RAM, battery, real-time clock, communication ports, and power supply as specified for an AN in Section 25 14 00 – Field Panels. Each gateway/router shall be mounted in a lockable enclosure unless it is a PC that also serves as an OWS.

2.2.4 The gateway/router shall allow centralized overall system supervision, operator interface, management report generation, alarm annunciation, acquisition of trend data, and communication with control units. It shall allow system operators to perform the

following functions from the CSS, OWSs, and POTs:

2.2.4.1 Configure systems.

2.2.4.2 Monitor and supervise control of all points.

2.2.4.3 Change control setpoints.

2.2.4.4 Override input values.

2.2.4.5 Override output values.

2.2.4.6 Enter programmed start/stop time schedules.

2.2.4.7 View and acknowledge alarms and messages.

2.2.4.8 Receive, store and display trend logs and management reports.

2.2.4.9 Upload/Download programs, databases, etc. as specified.

2.2.5 Upon loss of power to the gateway, the battery shall provide for minimum 100 hour backup of all programs and data in RAM.

2.2.6 The gateway shall be transparent to control functions and shall not be required to control information routing on the Primary LAN.

3 EXECUTION

3.1 PREPARATION

3.1.1 Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Subcontractor responsible for the installation of the BAS under the work of Division 25.

3.2 INSTALLATION

3.2.1 Installation shall meet or exceed all applicable federal, provincial, and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

3.2.2 All installation shall be in accordance with manufacturer's published recommendations.

3.2.3 Provide all interface devices and software to provide an integrated system.

3.2.4 Closely coordinate with the Owner, or designated representative, to establish IP addresses and communications to assure proper operation of the BAS with Owner's WAN.

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3.10 Unit Heaters
3.11 Miscellaneous Control Points

1 **GENERAL**

1.1 GENERAL

1.1.1 Sections 20 00 00 and 25 00 00 – General Requirements shall apply to and govern this Section.

1.2 SCOPE OF WORK

1.2.1 Refer to the below sequence of operation and associated control schematics for the required number of control loops. Provide all hardware and software necessary to achieve specified control. The sequence of events required for each control loop is described for each system in the control sequence.

1.2.2 Revise the controls shop drawing sequences of operation and create an "As-built or As Functioning Sequence of operation "to be included into the Operations and Maintenance Manuals.

1.2.3 The operators' workstation to include a Sequence of Operation tab to provide a narrative to the operator regarding equipment / system operation.

2 **PRODUCTS**

Not used.

3 **EXECUTION**

3.1 GENERAL

3.1.1 When motorized equipment is operating, BAS shall totalize runtime in hours for use in maintenance operations.

3.1.2 Where parallel or duplex equipment is provided, BAS shall alternate lead equipment such that runtime is equalized.

3.1.3 Provide adjustable time delay between damper or valve opening and equipment start/stop to avoid operation with a closed system.

3.1.4 Select components to fail safe. Priority in descending order is: life safety, protection of equipment, and comfort.

3.1.5 Schedule operation of systems according to schedules provided by the Owner, and/or optimal start/stop program, and/or Operator keyboard entry.

3.1.6 All low limit thermostats (freezestats), in addition to providing a DI control point, shall be hardwired to the equipment starter to shut down the system upon sensing an air temperature below 2°C (36°F).

3.1.7 Shut down fans upon detection (via BAS sensors) of supply or return air temperatures in excess of 67°C (135°F).

3.1.8 Co-ordinate the provision of duct mounted smoke detectors by Division 26 - Electrical. Detectors shall be hardwired to the respective fan starter to shut the fan down upon detection of smoke.

3.1.9 Co-ordinate fire alarm system fan shutdown where provided via the BAS with Division 26 - Electrical.

3.1.10 Fan systems shall not be started if motorized damper end switch indicates that the damper is not fully open. Alarm abnormal status of damper to BAS and start standby system if applicable.

3.1.11 Unscheduled shutdown of either the supply or return fan shall result in a system shutdown, and an abnormal status alarm condition at the BAS, and start-up of the standby system if applicable.

3.1.12 Static pressure control on all VAV air systems shall be sensed at a position 2/3 downstream of the supply fan. Shut system down if static pressure exceeds 498 Pa (2" w.c.)

3.1.13 Airside free cooling control shall be enabled based on enthalpy control.

3.1.14 All noted setpoints shall be operator-adjustable, and subject to tuning during system commissioning.

3.1.15 Status of motors shall be by current draw unless noted otherwise in the Contract Documents.

3.2 <u>LIFE SAFETY INTERFACE</u>

3.2.1 Division 26 – Electrical shall monitor and control all mechanical systems dedicated to life safety, notably the smoke control systems.

3.2.2 The BAS will control all fan shutdowns on fire alarm based on fire alarm zone annunciation via the fire alarm system.

3.3 GENERAL EXHAUST FAN

3.3.1 General exhaust airflow shall be read by the duct mounted airflow station downstream of the exhaust fan.

3.3.2 Fan shall be started if two (2) or more floors are occupied. Floor occupancy shall be indicated by the respective compartment unit status.

3.3.3 On start-up of the fan, the main exhaust air damper shall open. End switch at damper shall start the fan.

3.3.4 Variable frequency drive shall be modulated to maintain airflow setpoint. Setpoint shall be equal to the supply air volume of the make-up air unit less an amount for building pressurization, initially set at 236 L/s (500 cfm) per floor. Setpoint shall be adjustable. Building pressurization offset shall be adjustable.

3.3.5 Alarm at BAS if the fan status does not match fan command after 2 minutes.

3.3.5.1 Variable frequency drive shall have a minimum frequency setpoint of 20 Hz to prevent overheating of the motor.

3.4 ROOFTOP UNIT

3.4.1 Supply fan start/stop:

3.4.1.1 The supply fan will be started according to the schedule. After the supply fan has been started, the control sequence will be enabled.

3.4.1.2 Zone control:

3.4.1.2.1 The mixed air dampers, gas heating stages, and the dx cooling stages will modulate/cycle in sequence to maintain the zone temperature at setpoint.

3.4.1.2.2 Occupied Cooling Setpoint (adjustable): 22°C (+/- 1°C)

3.4.1.2.3 Occupied Heating Setpoint (adjustable): 20°C (+/- 1°C)

3.4.1.3 Economizer dry bulb switchover:

3.4.1.3.1 When the shared outside air temperature is below the switchover setpoint, the economizer will be enabled. When the shared outside air temperature rises above the switchover setpoint plus a differential, the economizer will be disabled.

3.4.1.4 Night setback/night setup:

3.4.1.4.1 When in "unoccupied" mode, the unit will cycle as necessary to maintain the night setback zone temperature at setpoint. A differential prevents the unit from cycling excessively.

3.4.1.4.2 Unoccupied Cooling Setpoint (adjustable): 25°C (+/- 1°C)

3.4.1.4.3 Unoccupied Heating Setpoint (adjustable): 18°C (+/- 1°C)

3.4.1.5 Shutdown:

3.4.1.5.1 When the unit is shut down by either a stop command or system safety the unit will be set as follows:

Supply fan will be off
Outside air damper will close
Return air damper will open
DX cooling will be off
Gas heat will be off

3.5 <u>SANITARY EXHAUST FAN</u>

3.5.1 Fan shall be scheduled from the BAS to start 30 minutes before any of the compartment units is scheduled to start. During unoccupied hours, the fan will only run if a compartment unit has been started by the VAV zone occupancy override.

3.5.2 On start-up of the fan, the main exhaust air damper shall open. End switch at damper shall start the fan.

3.5.3 Alarm at BAS if the fan status does not match fan command after 2 minutes.

3.6 <u>GAS FIRED MAKE-UP AIR UNIT</u>

3.6.1 Building supply airflow shall be read by the duct mounted airflow station down stream of MUA-1.

3.6.2 Unit off:

3.6.2.1 This mode is initiated by loss of supply fan status. Outdoor damper is closed. Gas burner is off. Humidifier is off. Supply fan is off.

3.6.3 Start-up:

3.6.3.1 Start-up is initiated by time of day schedule integral to the DDC controller. During unoccupied hours, the unit shall be enabled whenever any one compartment unit starts.

3.6.3.2 Outdoor damper opens. End switch on damper shall start the supply fan.

3.6.4 Temperature Control:

3.6.4.1 Supply air temperature setpoint is reset by outdoor air temperature. On a call for heating, the gas burner shall be enabled and modulated to maintain supply air temperature.

3.6.4.2 Setpoint reset shall be adjustable at BAS. Initially set as follows:

3.6.4.2.1 OAT < 4.4°C (40°F), Setpoint = 15.6°C (60°F).

3.6.4.2.2 OAT > 12.8°C (55°F), Setpoint = 12.8°C (55°F).

3.6.4.2.3 4.4°C (40°F) < OAT < 12.8°C (55°F), Setpoint is linear between above values.

3.6.4.3 Manufacturer's safety devices (high limit, air proving switch) shall be wired to humidifier to prevent unsafe conditions. The BAS shall monitor duct relative humidity down stream of the humidifier grid to ensure that the supply air humidity level never exceeds 90% RH. Approaching this limit, the BAS shall modulate back the demand signal to the humidifier.

3.6.5 Static Pressure Control:

3.6.5.1 Static pressure sensor shall be located 2/3 of the way down the longest run of supply ductwork. Bypass damper shall modulate to maintain supply air static setpoint. This setpoint shall be set by the air balancer.

3.6.5.2 Alarm at BAS if fan status does not match fan command after 2 minutes.

3.7 <u>ELEVATOR MACHINE ROOM AC UNIT</u>

3.7.1 The elevator machine room unit fan shall run continuously.

3.7.2 The mechanical cooling shall be cycled by switching the fan from low speed to high speed and cycling the DX cooling as required to maintain room setpoint temperature of 23.9°C (75°F).

3.7.3 Monitor the unit for temperature, status, and alarm.

3.8 MECHANICAL ROOM VENTILATION

3.8.1 Through a DDC controller, a space temperature sensor shall sequence the unit heaters, and the supply and exhaust fans to maintain space setpoint temperature according to the following schedule:

- Unit heaters on below 18.9°C (65°F)
- Unit heaters off above 20°C (68°F)
- Supply and exhaust fans on above 23.9°C (75°F)

3.9 MISCELLANEOUS EXHAUST FANS

3.9.1 When exhaust fan is off, close respective damper.

3.9.2 When exhaust fan is activated based on time of day schedule, open damper before starting fan.

3.10 UNIT HEATERS

3.10.1 Unit heaters shall be controlled by line voltage remote reverse acting thermostat. No control valve is required. Set all thermostats at 20°C (68°F). Deadband shall be 1.1°C (2°F). Unit heater shall shut off at 21.1°C (70°F).

3.11 MISCELLANEOUS CONTROL POINTS

3.11.1 Monitor the following additional points via the BAS.

MISCELLANEOUS CONTROL POINTS			
DESCRIPTION	**LOCATION**	**TYPE**	**REMARKS**
Sump Pumps	Sump Pump Control Panel	DI	Alarm High Level (6x)

END OF SECTION

Standard Building Automation System (BAS) Owner Requirements

November, 2019

Version & revision number: 6.1.6

APPENDIX A

This document is the standard for use in new construction, retrofits and upgrades in City of Toronto facilities and shall not be amended in any way without written consent from the Corporate Real Estate Management (CREM) Division.

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****
This section includes the central building automation system components and network protocol specifications. It may be used as section 23 09 23 or 23 09 93 depending on specification format used.

In addition to this section it will be necessary to add project specific sections for control components and sequences of operation.
The intent of this specification is to describe the minimum features required for a new installation. For renovation or refit type projects, it will be necessary to determine to what extent any existing system can be upgraded or modified within the parameters of the project budget to achieve the general intent of this specification and provide appropriate edits.
****

PART 1 - GENERAL

1.0 GENERAL REQUIREMENTS

1.1 Conform to all, “Mechanical General Provisions”.

1.2 The "provide" in this Division shall be interpreted as "supply and install".

1.3 All work shall conform to Canadian Metric Practice Guide CSA CAN3-2234.1.76

1.4 Provide all required adapters between metric and imperial components.

1.5 Metric descriptions in this Division are nominal equivalents of Imperial values.

1.6 All equipment and material to be new, CSA certified, manufactured to minimum standard quoted including additional specified requirements.

1.7 Where there is no alternative to supply equipment that is not CSA certified, submit such equipment to Inspection Authorities for special inspection and obtain approval before delivery of equipment to site.

1.8 Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by the owner. Spare parts shall be available for at least five years after completion of this contract.

1.9 Use material and equipment available from a regular production by manufacturer concerned.

2.0 WORK INCLUDED

****
Add to this section any site specific qualifications that may apply to the specific project with respect to application of the specified requirements for the system.
****

2.1 The City of Toronto has standardized Building Automation Systems utilizing native BACnet area, system and application controllers. Extend the existing Framework as detailed herein.

2.2 The system shall support standard Web browser access via the City's Intranet/Internet. It shall support a minimum of 100 simultaneous users with the ability to access the graphical data and real time values simultaneously. (Refer to Section 7.16)

2.3 Provide an open protocol Building Automation System (BAS) incorporating Direct Digital Control (DDC), equipment monitoring, and control consisting of: A PC based Operator Work Station (OWS) with colour graphic data displays; Microcomputer based Building Controllers (BCs) and Microcomputer based Advanced Application Controllers (AACs) and Application Specific Controllers (ASCs) interfacing **directly** with sensors,

actuators and environmental delivery systems (i.e., HVAC units, boilers, chillers, lighting systems, etc.); electric controls and mechanical devices for all items indicated on drawings described herein including dampers, valves, panels and compressed air plant.

2.4 City of Toronto has standardized the use of Direct Digital Controllers (DDC) and End Devices. No **NEW** pneumatic control devices shall be connected or incorporated into the BAS network. It applies to new installations as well as retrofit applications.

2.5 Open Protocols by definition are to be BACnet (ASHRAE Standard 135 – Annex J) and Haystack only.

2.6 Provide BAS controllers (BCs, AACs and ASCs) based on native BACnet (ASHRAE Standard 135 – Annex J) protocols.

2.7 Provide submittals, data entry, electrical installation, programming, startup, test and validation acceptance documentation, and system warranty.

3.0 WORK BY OTHERS

3.1 Access doors and setting in place of valves, flow meters, water pressure and differential taps, flow switches, thermal wells, dampers, air flow stations, and current transformers shall be by others.

4.0 QUALITY ASSURANCE

4.1 Codes and Approvals:

4.1.1 Work, materials, and equipment shall comply with the Ontario Building Code, Ontario Electrical Code, ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACnet) and Authorities having jurisdiction over this work. All devices shall be ULC, UL or FM listed and labeled for the specific use, application and environment to which they are applied.

4.1.2 The BAS shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air Conditioning.

4.1.3 All electronic equipment shall conform to the requirements of CSA for electromagnetic emissions standards and placed in approved locations such that it does not interfere with building equipment or computers.

4.2 Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be AC coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

5.0 ABBREVIATIONS AND SYMBOLS

5.1 All letter symbols and engineering unit abbreviations utilized in information displays ANSI/ISA S5.5 and printouts shall conform to ANSI 710.19/IEEE 260-letter symbols for SI and certain other units of measurement.

5.2 Specification Nomenclature - Acronyms used in this specification are as follows:

AAC Advanced Application Controller
ASC Application Specific Controller
BAS Building Automation System
BC Building Controller

BIBB BACnet Interoperability Building Blocks
DDC Direct Digital Controls
GUI Graphical User Interface
HTTP Hyper Text Transfer Protocol
LAN Local Area Network
ODBC Open Database Connectivity protocol
OOT Object Oriented Technology
OPC Object linking and embedding for Process Control
OWS Operator Workstation
PDA Personnel Data Assistant device
PICS Protocol Implementation Conformance Statement
PWS Portable Workstation
SNVTS Standard Network Variables Types
SQL Standard Query Language
TCP/IP Transmission Control Protocol / Internet Protocol
TCU Terminal Control Unit
WAN Wide Area Network
WAP Wireless Application Protocol device
WBI Web Browser Interface
XML Extensible Markup Language
XIF External Interface Files

6.0 APPROVED CONTROL SYSTEMS

****
Applicable to new construction projects, new installations within existing buildings and major retrofit/overhaul of existing BAS systems.
****

6.1 Any vendors that are authorized dealers or distributors of the following control systems are acceptable:

6.1.1 Delta Controls
6.1.2 Reliable Controls
6.1.3 Schneider Electric SmartX series
6.1.4 Distech Controls
6.1.5 Johnson Controls Facility Explorer
6.1.6 Honeywell CIPer series, Spyder models 5 or 7

6.2 BAS Systems Integration:

6.2.1 All control systems must be integrated to the City's J2 Innovations Fluid Integration (FIN) server, including but not limited to the following:
6.2.1.1 graphical user interface (monitoring & control)
6.2.1.2 alarming
6.2.1.3 data trending
6.2.1.4 data archiving
6.2.1.5 Project Haystack naming convention

6.2.2 The installer must be licensed by J2 Innovations to sell, install, program and configure Fluid INtegration (FIN).

6.2.3 Building Controllers (BC) must be Tridium Niagara JACE with the Haystack module and driver. The installer must be a licensed Tridium system integrator for any Tridium BCs or embedded or edge Niagara Framework products used. Soft JACE is not accepted.

6.3 Licensing Requirements

6.3.1 Licenses shall be provided to and in the name of the City of Toronto
6.3.2 Licenses shall be perpetual, transferrable, assignable and royalty-free

6.3.3 Tridium licenses shall allow all Workbench/Supervisor brands complete system access and functionality.

6.4 Installer and Manufacturer Qualifications

6.4.1 Installer shall have an established working relationship with Control System Manufacturer.

6.4.2 Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

6.4.3 It is the intent of this specification to define an open protocol state-of-the-art distributed computerized Building Management and Control System which is user friendly, has known reliability, is extremely responsive, and which is to be designed, installed, implemented, and supported by a local office of approved bidders.

6.4.4 BAS contractor shall provide three locations of successful installations of similar open protocol computer based systems. Sites provided must consist of more than 150 hardware inputs/outputs. Project sites must be local to the location of this project.

6.5 System Administration

6.5.1 Administrator credentials shall be sent to BAS@Toronto.ca for retention by the City. Credentials shall include any and all accounts and passwords required for complete system access, including but not limited to Station and Platform credentials.

7.0 SYSTEM DESIGN

****

For retrofit projects where a gateway might be considered the most appropriate economic decision for interface to an existing automation system, remove article 7.2.

****

7.1 The system shall consist of a network of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), and Smart Actuators (SA). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

7.2 Systems utilizing gateways will not be considered. A gateway device is considered to be a device where only mapping of system points from one protocol to another occurs. A gateway device cannot perform higher-level energy management functions such as Outdoor Air Optimization, Electrical Demand Limiting and the like.

7.3 The Building Automation System software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a BAS server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

7.4 A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a flat single tiered architecture shall not be acceptable. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

8.0 BACnet.

8.1 Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.

8.2 Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

8.3 Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.

8.4 Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

8.5 Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

8.6 BACnet Communication.

8.6.1 Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.

8.6.2 BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.

8.6.3 Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

8.6.4 Each ASC shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

8.6.5 Each SA shall reside on a BACnet network using the MS/TP Data Link/Physical layer protocol.

8.6.6 Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using MS/TP Data Link/Physical layer protocol.

8.6.7 The maximum number of controllers on an MS/TP network/subnet shall be no more than 30 or the manufacturer recommended limit, whichever is less.

8.6.8 An approved addressing scheme must be obtained from BAS@Toronto.ca and be included on project shop drawings (specifically the BAS network architecture diagrams) prior to installation. Buildings without approved schemes shall not exist on the City WAN.

8.6.9 BAS shall transfer data between controllers on a stand-alone BAS network. One (1) data drop per building will be provided to establish connection to central server. Should back end programming and configuration be inaccessible via this one (1) data drop, an additional data drop will be provided to allow City BAS Team to communicate to the base building control system using manufacturer software tools.

8.6.10 Access to City central servers will <u>not</u> be provided during construction. Database and graphics are merged with central server after project deficiency lists have been cleared (including graphics deficiencies). This merging must be coordinated with the application

administrators (BAS@Toronto.ca).

8.6.11 The City Ethernet connection shall be fully segregated and isolated from the BAS LAN via the secondary BC Ethernet port. A City static IP address will be provided by Technical Services Division (TSD) for this connection. The City's divisional project manager or designate will coordinate this request.

8.6.12 Third party devices shall be connected on a dedicated subnet that is separate from the base control system network(s).

9.0 COMMUNICATION

9.1 Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

9.2 Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

9.3 Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

9.4 Stand-Alone Operation. Each piece of equipment specified in the sequence of operation shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

10.0 ENVIRONMENT

Controller hardware shall be suitable for anticipated ambient conditions.

10.1 Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

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

11.0 REAL-TIME CLOCK

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

12.0 SERVICEABILITY

12.1 Controllers shall have diagnostic LEDs for power, communication, and processor.

12.2 Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

12.3 Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

13.0 MEMORY

13.1 Controller memory shall support operating system, database, and programming requirements.

13.2 Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

13.3 Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

14.0 IMMUNITY TO POWER AND NOISE

14.1 Controllers 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).

15.0 POWERFAIL RESTART

15.1 In the event of the loss of normal power, there shall be an orderly shutdown of all controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

15.2 Upon restoration of normal power, the controller shall automatically resume full operation without manual intervention. The controllers shall incorporate random start sequences to ensure a power spike does not result.

15.3 Controller memory shall not be lost during a power failure.

15.4 The user shall have the capability of loading or re-loading all software via the OWS or the local terminal port.

16.0 DYNAMIC DATA ACCESS

16.1 All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

17.0 INPUT AND OUTPUT INTERFACE

17.1 General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

17.2 Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

17.3 Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

17.4 Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

17.5 Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

17.6 Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

17.7 Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

17.8 Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

17.9 Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

18.0 POWER SUPPLIES AND LINE FILTERING

18.1 Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with CEC requirements. Limit connected loads to 80% of rated capacity.

18.1.1 DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes.

Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

18.1.2 Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

18.1.3 Line voltage units shall be UL recognized and CSA listed.

18.2 Power Line Filtering.

18.2.1 Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

18.2.1.1 Dielectric strength of 1000 V minimum

18.2.1.2 Response time of 10 nanoseconds or less

18.2.1.3 Transverse mode noise attenuation of 65 dB or greater

18.2.1.4 Common mode noise attenuation of 150 dB or greater at 40-100 Hz

19.0 AUXILIARY CONTROL DEVICES

19.1 Electric Damper and Valve Actuators.

19.1.1 Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

19.1.2 Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

19.1.3 Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 16.8)

19.1.4 Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

19.1.5 Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

19.2 Binary Temperature Devices.

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

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

19.2.3 Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

19.3 Temperature Sensors

19.3.1 Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor (10K).

19.3.2 Duct Sensors. 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.

19.3.3 Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

19.3.4 Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port.

19.3.5 Differential Sensors. Provide matched sensors for differential temperature measurement.

19.4 Humidity Sensors.

19.4.1 Differential Sensors. Provide matched sensors for differential temperature measurement.

19.4.2 Duct and room sensors shall have a sensing range of 20%-80%.

19.4.3 Duct sensors shall have a sampling chamber.

19.4.4 Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°C-75°C (40°F-170°F).

19.4.5 Humidity sensors shall not drift more than 1% of full scale annually.

19.5 Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service). Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

19.5.1 Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.

19.5.2 Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

19.6 Relays.

19.6.1 Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

19.6.2 Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

19.7 Override Timers.

19.7.1 Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

19.8 Current Transmitters.

19.8.1 AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

19.8.2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

19.8.3 Unit shall be split-core type for clamp-on installation on existing wiring.

19.9 Current Transformers.

19.9.1 AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

19.9.2 Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

19.9.3 Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

19.10 Voltage Transmitters.

19.10.1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

19.10.2 Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

19.10.3 Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

19.11 Voltage Transformers.

19.11.1 AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

19.11.2 Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

19.11.3 Windings (except for terminals) shall be completely enclosed with metal or plastic.

19.12 Power Monitors.

19.12.1 Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.

19.12.2 Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

19.13 Current Switches.

19.13.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

19.14 Pressure Transducers.

19.14.1 Transducers shall have linear output signal and field-adjustable zero and span.

19.14.2 Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.

19.14.3 Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.

19.14.4 Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.

19.15 Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

20.0 NETWORKS

20.1 BAS contractor to coordinate with the City's IT department for the connections to the City's Network.

20.2 Design for the Network LAN (BC LAN) shall include the following provisions:

20.2.1 Provide access to the BC LAN from a remote location, via the Intranet.

20.2.2 The network LAN shall utilize BACnet/IP (ASHRAE standard SPC-135A-2004 - Annex L) for communication between BCs. Manufacturer specific proprietary protocols, gateways, or protocol converters are not acceptable for this project. The OWS shall communicate to the BCs utilizing standard Ethernet to IEEE 802.3 Standards.

20.2.3 High-speed data transfer rates for alarm reporting, quick report generation form multiple controllers and upload/download efficiency between network devices.

20.2.4 Detection and accommodation of single or multiple failures of workstations, controller panels and the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

20.2.5 Message and alarm buffering to prevent information from being lost.

20.2.6 Error detection, correction, and retransmission to guarantee data integrity.

20.2.7 Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

20.2.8 Commonly available, multiple sourced, networking components shall be used to allow the system to coexist with other networking applications such as office automation. ETHERNET is the only acceptable technology.

20.2.9 Synchronization of the real-time clocks in all BC panels shall be provided.

20.2.10 The BC LAN shall be a 100 Megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Building Controllers (BCs), user workstations and where specified, a local server. Local area network minimum physical and media access requirements:
20.2.10.1 Ethernet; IEEE standard 802.3

20.2.10.2 Cable; 100 Base-T, UTP-8 wire, category5
20.2.10.3 Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

20.2.11 Provide access to the BC LAN via a Wireless Application Protocol (WAP) device as well. Through this connection the BC LAN will provide authorized staff with the ability to monitor and control the BAS from any location within the City network through a web browser, cellular phone, pager, WebPads, or PDA. (Pocket Computer).

21.0 SERVER FUNCTION

21.1 Local connections shall be via an Ethernet LAN.

21.2 It shall be possible to provide access to all Building Control Units (BC) via a single connection to the server. In this configuration, each Building Control Unit (BC) can be accessed from an Operator Workstation (OWS) using a standard Web browser by connecting to the BAS LAN. The server shall provide the following functions, as a minimum:

21.2.1 Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
21.2.2 Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any Building Control Unit (BC) in the network, local or remote.
21.2.3 The server shall include a master clock service for its subsystems and provide time synchronization for all Building Control Units (BC).
21.2.4 The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
21.2.5 The server shall provide scheduling for all Building Control Units and their underlying field control devices.
21.2.6 The server shall provide demand limiting that operates across all Building Control Units. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shedding lists for effective demand control.
21.2.7 The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Building Control Units. Systems not employing this prioritization shall not be accepted.
21.2.8 Each Building Control Unit supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
21.2.9 The server shall provide central alarm management for all Building Control Units supported by the server. Alarm management shall include:
21.2.10 Routing of alarms to display, printer, email and pagers
21.2.11 View and acknowledge alarms
21.2.12 Query alarm logs based on user-defined parameters
21.2.13 The server shall provide central management of log data for all Network Control Units supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
21.2.14 Viewing and printing log data
21.2.15 Exporting log data to other software applications
21.2.16 Query log data based on user-defined parameters
21.2.17 Minimum BACnet features supported are
-Standard BACnet Objects (Analog In/Out/Value, BinaryInput/Output/Value, Multi-State -- Input/Output/Value, Schedule(export), Calendar(export), Trend(Export), Device).
-Segmented Capability (Segmented Request-Segmented Response).
-Application Services (Read Property, Read Property Multiple, Write Property, Write Property Multiple, Confirmed Event, Notification, Acknowledge Alarm, Get Alarm Summary Who-has, I-have, Who-is, I-am, Subscribe COV, Confirmed COV notification, Unconfirmed COV notification).

-BACnet Broadcast Management

22.0 SCOPE OF WORK

22.1 The work covered by this specification and related sections consists of providing shop drawings, equipment, labour, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

22.1.1 The preparation of submittals and provision of all related services.

22.1.2 Operator workstations located as listed in the specifications **(OWS will be provided by the City's IT, SEE PART 2, SECTION 1.1.4).**

22.1.3 Furnish and install all controllers to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

22.1.4 Furnish and load all software required to implement a complete and operational BAS.

22.1.5 Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.

22.1.6 Perform acceptance tests, commissioning or re-commissioning as indicated.

22.1.7 Provide full documentation for all application software and equipment.

22.1.8 Miscellaneous work as indicated in these specifications.

23.0 PERMITS, FEES AND CODES

23.1 Apply for, obtain and pay for all permits, licenses, inspections, examinations and fees required. Also submit, if required, information and other data that may be obtained from the Engineer. Should the authorities require the information on specific forms, fill in these forms by transcribing the information provided by the Engineer.

23.2 BAS contractor shall obtain and pay for the police clearance certificates if required for the project.

23.3 Arrange for inspection of all work by the authorities having jurisdiction over the Work. On completion of the Work, present to the Engineer the final unconditional certificate of approval of the inspecting authorities.

23.4 Comply with the requirements of the latest edition of the applicable ULC or CSA standards, the requirements of the Authorities, Federal, Provincial/Territorial and Municipal Codes, the applicable standards of ULC and all other authorities having jurisdiction. These Codes and Regulations constitute an integral part of these Specifications.

23.5 Where there is no alternative to supply equipment which is CSA certified, submit such equipment to the local electrical authority for special inspection and obtain approval before delivery of equipment to site.

23.6 In case of conflict, applicable Codes take precedence over the Contract Documents. In no instance reduce the standard or Scope of Work or intent established by the Drawings and Specifications by applying any of the Codes referred to herein.

23.7 Before starting any work, submit the required number of copies of documentation to the authorities for their approval and comments. Comply with any changes requested as part of the Contract, but notify the

Engineer immediately of such changes, for proper processing of these requirements. Prepare and furnish any additional drawings, details or information as may be required.

24.0 COORDINATION

24.1 All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer/Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.

24.2 Organize all sub-contractors and ensure that they maintain the schedule.

24.3 Full cooperation shall be shown with other sub-contractors to facilitate installations and to avoid delays in carrying out the work.

24.4 Notify Engineer/Construction Manager of any changes to the schedule. Send any schedule changes and weekly progress reports via fax to Engineer/Construction Manager.

24.5 Where, in the judgment of the Engineer/Construction Manager, the work could disrupt the normal operations in or around the building, contractor shall schedule work to eliminate or minimize interference, subject to owner's approval.

24.6 When connecting to the existing systems, advise the Engineer/Construction Manager and obtain permission to so. Perform work at a time acceptable to the Engineer/Construction Manager and Owner.

24.0 SUPERVISION OF PERSONNEL

24.1 Maintain at this building qualified personnel and supporting staff with proven experience in erecting, supervising, testing, and adjusting projects of comparable nature and complexity.

24.2 Supervisory personnel and their qualifications are subject to the approval of the Owner.

24.3 All personnel working on-site shall sign in as required by the Owner and shall wear company identification.

24.4 When requested and for whatever reason, remove personnel and/or support staff from project. Take immediate action. Contractors and subcontractors may require police clearance.

25.0 ELECTRICAL WORK AND SAFETY REQUIREMENTS

25.1 Control and interlock wiring and installation shall comply with national and local electrical codes, and manufacturer's recommendations.

25.2 CEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by CEC.

25.3 Low-voltage wiring shall meet CEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.

25.4 CEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

25.5 Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

25.6 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).

25.7 Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

25.8 Do not install wiring in raceway containing tubing.

25.9 Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 3 m (10 ft) intervals.

25.10 Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

25.11 Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

25.12 Size raceway and select wire size and type in accordance with manufacturer's recommendations and CEC requirements.

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

25.14 Use color-coded conductors throughout.

25.15 Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

25.16 Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.

25.17 Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

25.18 Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

25.19 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. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

25.20 Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

25.21 All equipment and systems installed under this Contract shall be grounded, isolated, or conditioned as required to permit equipment to continue to function normally, without interruption, in the event of radio frequency interference (RFI), electromagnetic interference (EMI), power surges/dips or other electrical anomalies.

25.22 It shall be the responsibility of the Contractor or his Sub-contractor to ensure that any coring of holes through the walls or floors will not penetrate existing conduits, cables or mechanical equipment in or under the floor slabs or walls. He shall be responsible to take any and all action as deemed necessary by the Project Manager to correct any such penetrations at his cost. No coring shall be undertaken unless the Project Manager gives permission. Scan walls and floors prior to core drilling to identify hidden piping. Ensure that water does not flow into equipment and below floors. Waterproof and fire stop all penetrations.

26.0 COMMUNICATION WIRING

26.1 Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 25 (Electrical Work).

26.2 Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

26.3 During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

26.4 Verify entire network's integrity following cable installation using appropriate tests for each cable.

26.5 Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

26.6 Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

26.7 Label communication wiring to indicate origination and destination.

26.8 Ground coaxial cable according to OEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

27.0 LOCKABLE PANELS

27.1 Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.

27.2 Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.

27.3 Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

28.0 WARNING LABELS

28.1 All Controller panelsAffix permanent warning labels to equipment that can be automatically started by the control 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.

B. Affix permanent warning labels to motor starters and 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.

29.0 IDENTIFICATION OF HARDWARE AND WIRING

29.1 Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

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

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

29.4 Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement (lamacoids).

29.5 Label room sensors related to terminal boxes or valves with nameplates (lamacoids).

29.6 Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

29.7 Label identifiers shall match record documents.

29.8 Insert laminated points list in the control panel

30.0 PRELIMINARY DESIGN REVIEW

30.1 The BAS contractor shall submit a preliminary design document for review. This document shall contain the following information:

30.1.1 Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification.

30.1.2 Provide product data sheets and a technical description of BC, AAC, ASC hardware required to meet specifications listed herein.

30.1.3 Provide product brochures and a technical description of the Server, Operator Workstation, and Building Control Unit (BC) software required to meet this specification. Provide a description of software programs included.

30.1.4 Open Protocols - For all hardware Building Controllers, Advanced Application Controllers (AAC) and Advanced Specific Controllers (ASC), provide BACnet Interoperability Building Blocks BIBBs certification. Provide complete description and documentation of any proprietary services and/or objects where used in the system.

30.1.5 Provide a description and samples of Operator Workstation graphics and reports.

30.1.6 Provide an overview of the BAS contractor's local/branch organization, local staff, recent related project experience with references, and local service capabilities.

30.1.7 Provide information on the BAS contractors project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

31.0 DRAWING REQUIREMENTS

31.1.1 Within 45 days of award of contract and before start of construction, submit 3 hard copies and 1 soft copy of manufacturers information and shop drawings. Soft copy to be in AutoCAD or VISIO and WordPerfect or Word formats (latest versions) structured using menu format for easy loading and retrieval on the OWS.

31.1.2 Manufacturer's Data: Provide in completely coordinated and indexed package to assure full compliance with the contract requirements. Piecemeal submittal of data is not acceptable and such submittals will be returned without review. Information shall be submitted for all material and equipment the contractor proposes to furnish under terms of this contract work. Arrange the

submittals in the same sequence as these specifications and reference at the upper right-hand corner the particular specification provision for which each submittal is intended. Submittals for each manufactured item shall be manufacturer's descriptive literature (equipment specification), equipment drawings, diagrams, performance and characteristic curves, and catalog cuts, and shall include the manufacturer's name, trade name, catalog model or number, nameplate data, size layout dimension, capacity, specification reference, applicable specification references, and all other information necessary to establish contract compliance.

31.1.3 Shop drawings: Provide in completely coordinated and indexed package:

31.1.3.1 Wiring and piping diagrams.

31.1.3.2 Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.

31.1.3.3 Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details (CDL's) associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.

31.1.3.4 Detailed system architecture showing all points associated with each controller, controller locations, and describing the **spare points capacity** at each controller and BAS LAN.

31.1.3.5 Each BC shall contain a minimum of 20% spare resource capacity. The BC shall provide a throughput capable of transmitting all BAS LAN data connected to it within 10 seconds.

31.1.3.6 Each AAC and ASC shall have a minimum of 10% spare capacity for each point type for future point connection. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. As a minimum, provide one of each type of point available on the controller.

31.1.3.7 Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc

31.1.3.8 Colour graphic displays detailing hierarchical structure of facility, including floor plans, with multi-level penetration to equipment level.

32.0 START-UP AND CHECKOUT

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City's BAS Project Manager shall be present during the Start-Up and Checkout- FOR FACILITIES MANAGEMENT PROJECTS ONLY, FOR OTHER DIVISIONS THIS IS OPTIONAL

****

32.1 This work shall include field testing and adjustment of the complete BAS, and on-site final operational acceptance test of the complete operational BAS. The Engineer shall be advised at least 14 days in advance of the dates of all tests and may attend at his discretion. If the Engineer witnesses the test, such tests shall be subject to his approval prior to the release of equipment. If the Engineer elects not to witness the tests, the contractor shall provide performance certification. Acceptance of tests by the Engineer and Project Manager shall not relieve the contractor of responsibility for the complete system meeting the requirements of these specifications after installation.

32.2 Static testing:

32.2.1 Static testing shall include point-by-point testing of the entire system and completion of Component Test Sheets. The contractor shall forward proposed Test Sheets at the shop drawing review stage. These Component Test Sheets shall be completed during the contractor's own testing and verification procedure that is done prior to the request for a final inspection. The completed Component Test Sheets shall then be returned to the Engineer for review and approval. The Engineer may repeat a random sampling of at least 50% of the tests during the Engineers commissioning procedure to corroborate their accuracy. The Contractor shall be on site with test equipment during this verification process. The test procedures shall include the following.

32.2.1.1 Digital input component test sheet:

32.2.1.1.1 DI status shall be verified at the POT and OWS for ON and OFF status.

32.2.1.1.2 All digital alarm inputs shall be proven using actual field conditions where possible or be jumpered at the field device for testing with the approval of the Engineer.

32.2.1.2 Digital output component test sheet:

32.2.1.2.1 Status to be verified at the equipment location. Verification at the OWS shall be completed for ON and OFF status, software DISABLE indicator and OVERRIDEN indicator

32.2.1.3 Analog input component test sheet:

32.2.1.3.1 All temperature sensors shall be calibrated using a hand held meter with equal or better accuracy.

32.2.1.3.2 Selected temperature sensors chosen by the Engineer shall be verified by spraying with a cold spray or other means to ensure response and to test the low temperature alarm condition.

32.2.1.3.3 All pressure sensing devices and analog output feedback shall be verified using a device with equal or better accuracy to ensure correct calibration.

32.2.1.3.4 All humidity sensing devices must be verified using a recently calibrated device with equal or better accuracy

32.2.1.3.5 All CTs shall be set to accurately reflect motor status, including removing belts on belt driven equipment

32.2.1.3.6 All other devices shall be verified using appropriate devices of equal or better accuracy

32.2.1.3.7 Adjust span on feedback devices so that input matches the end device

32.2.2 Analog output component test sheet:

32.2.2.1 AI points shall be tested by sending a command from the PWS or OWS to incrementally stroke the field device from full CLOSED to full OPEN and measuring the signal at the field device. The increments of the test shall be no larger than 10% of the output span.

32.2.2.2 The AO feedback requirement shall also be tested by failing the field device and verifying that the alarm registers

32.2.2.3 Each output shall be exercised over the full output capability of the panel

32.2.2.4 Field device hysteresis shall be measured at a minimum of three output levels for each direction of travel. Output increments shall not exceed 2% of span for this test

33.0 STANDARDS COMPLIANCE

33.1 Where materials or equipment are specified to conform to requirements of the standards of organizations, such as the Canadian Standards Association (CSA) that use a label or listing as method of indicating compliance, proof of such conformance shall be submitted and approved, indexed and cross-referenced with the specification. The label or listing of the specified organization will be acceptable evidence. In lieu of the label or listing, the contractor shall submit a certificate from a testing organization adequately equipped and competent to perform such services, and approved by the Engineer, stating that the item has been tested in accordance with the specified organization's test methods and that the item conforms to the specified organization's standard or code. For materials whose compliance with organizational standards or specifications is not regulated by an organization using its own listing or label as proof of compliance, a certificate from the manufacturer shall be furnished to the Engineer stating that the material complies with the applicable referenced standard or specification.

34.0 FINAL ACCEPTANCE

34.1 Final acceptance shall commence only after satisfactory completion of start-up, verification of performance and the 30-day test period described earlier. When the Contractor has satisfied himself as to proper system operation he shall advise the BAS Commissioning Engineer/Consultant to establish a date for Final Acceptance. This will involve a point-by-point check of all hardware and software items including graphics and displayed data, as well as performing tasks as directed.

34.2 Supply 2-way radios and all test equipment as previously specified. Have on-site technical personnel capable of re-calibrating all field hardware and modifying software.

34.3 Test each system independently and then in unison with other related systems. Test weather sensitive systems twice- once near winter design conditions and again near summer design conditions.

34.4 Optimize operation and performance of each system. Test full-scale emergency operation and integrity of smoke management and other life safety systems.

34.5 Demonstrate to the Engineer the operation of each system including sequence of operations in regular and emergency modes, under all normal and emergency conditions, start-up, shut-down, interlocks, and lock-outs.

34.6 Upon completion of the testing submit a report to the Engineer to summarize all testing.

35.0 DOCUMENTATION

35.1 Documentation shall consist of 4 hard copies and one soft copy for all information described below

35.2 The final documentation package shall include:

35.2.1 Hard and soft copies of all control drawings (As-Builts).

35.2.2 Manufacturer’s technical data sheets for all hardware and software

35.2.3 Factory operating and maintenance manuals with any customization required

35.2.4 Soft copies of programming and front-end software and each controller’s database. Hard copy output of programming is not necessary

35.2.5 Provide clear, concise, typewritten and soft copy descriptions of all control sequences in the working language.

35.2.6 Soft copy text files shall be in MS-Word.

35.3 Each instruction and reference manual shall be bound in hardback, 3 ring, binders or an approved equivalent shall be provided to the Engineer. Binders to be no more than 2/3 full. Each binder to contain index to full volume. One complete set of manuals shall be furnished prior to the time that the system or equipment tests are performed, and the remaining manuals shall be furnished at acceptance. The identification of each manual's contents shall be inscribed on the cover and spine. The manuals shall include the names, addresses and telephone numbers of each subcontractor installing equipment systems and of the local representatives for each item of equipment and each system. The manuals shall have a table of contents and be assembled to conform to the table of contents with the tab sheets placed before instructions covering the subject. Additionally, each manual shall contain a comprehensive index of all manuals submitted in accordance with this paragraph. Manuals and specifications shall be furnished which provide full and complete coverage of the following subjects:

35.4 Operational Requirements: This document shall describe in concise terms, all the functional and operational requirements for the system and its functions that have been implemented. It shall be written using common terminology for building operation staff and shall not presume knowledge of digital computers, electronics or in-depth control theory.

35.5 System Operation: Complete step by step procedures for operation of the system, including required actions at each operator station; operation of computer peripherals; input and output formats; and emergency, alarm and failure recovery. Step-by-step instructions for system startup, back-up equipment operation, and execution of all system functions and operating modes shall be provided.

35.6 Maintenance: Documentation of all maintenance procedures for all system components including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective module. This shall include calibration, maintenance, and repair or replacement of all system hardware.

35.7 Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures. A provision for the measurement or observation of results, based on the previously published test specification, forms the test reports. The procedures record and the results of these exercises shall be conveniently bound and documented together.

35.8 Configuration Control: Documentation of the basic system design and configuration with provisions and procedures for planning, implementing, and recording any hardware or software modifications required during the installation, test, and operating lifetime of the system. This shall include all information required to ensure necessary coordination of hardware and software changes, data link or message format/content changes, and sensor or control changes in the event system modification are required, and to fully document such new system configurations.

36.0 TRAINING

36.1 The Contractor shall provide the services of competent instructors who will provide instruction to designated personnel in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. The training shall be oriented towards the system installed rather than being a general "canned" training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The number of person-days (eight hours) of instruction furnished shall be as specified below as a minimum. A training manual shall be provided for each trainee that describes in detail the data included in each training program.

36.2 All equipment and material required for classroom training shall be provided by the contractor. A person-week shall be considered as 37.5 hours, 8:00 am to 12:00 noon, and 12:30 pm to 4:30 pm Monday through Friday. Provide 5 days of training as specified herein.

36.3 Training shall enable operators to accomplish the following objectives:

36.3.1 Proficiently operate system

36.3.2 Understand control system design and configuration

36.3.3 Create and change system graphics

36.3.4 Create, delete, and modify alarms, including configuring alarm reactions

36.3.5 Configure and run reports

36.3.6 Add, remove, and modify system's physical points

36.3.7 Create, modify, and delete application programming

36.3.8 Add a new controller to system

36.3.9 Download firmware and advanced applications programming to a controller

36.3.10 Configure and calibrate I/O points

36.3.11 Maintain software and prepare backups

36.3.12 Understand DDC system components

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

36.3.14 Operate workstation and peripherals

36.3.15 Log on and off system

36.3.16 Access graphics, point reports, and logs

36.3.17 Adjust and change system setpoints, time schedules, and holiday schedules

36.3.18 Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools

36.3.19 Access data from DDC controllers

36.3.20 Add new users and understand password security procedures

37.0 WARRANTY

37.1 Provide warranty certificates showing the name of the firm giving the warranty, dated from the issuance of the Certificate of Substantial Performance and acknowledged on specific equipment and systems.

37.2 Include these certificates with the Operation and Maintenance Manual in the appropriate sections.

37.3 Contractor shall give a minimum two-year warranty for parts and labor on all equipment and materials installed and shall select materials and equipment where the Manufacturer gives the same warranty arrangements. Warranty shall commence on the date of the Engineers issuance of the Certificate of Substantial Completion.

37.4 Provide a warranty as indicated in 38.0 - Maintenance/Service.

37.5 The Contractor shall agree to make good at his own expense any equipment that fails to operate due to poor workmanship, manufacturing defect or improper installation. Any repairs shall be made at the convenience of the Engineer during normal working hours, unless deemed an emergency.

37.6 Provide upgrades to all software or all panel firmware issued during the warranty period at no charge to Owner.

38.0 MAINTENANCE/SERVICE

****
BAS contractor to show the price of service contract as separate line item.
Applicable to New System Installations OR Major overhaul of existing BAS system/s
****

38.1 Provide warranty in accordance with the warranty section of this specification. In addition provide scheduled maintenance and service during the warranty period on all control system apparatus including but not limited to valves, dampers, linkages, control panels, interfaces, direct digital control systems, OWS, Server, BC, AAC, ASC, Software and application programs.

38.2 Scheduled preventive maintenance inspections will provide those services required to maintain the system at maximum performance and reliability levels and may include the following:

38.3 Analyze, adjust, calibrate the applicable temperature sensors, humidity sensors, diagnostic LEDs, printers, power supplies, work stations, controllers, modems, input/output points, communication cabling, transmitters, transducers, UPS for the BAS system.

38.4 Conduct inspections and thorough preventive maintenance routine on each piece of covered equipment. In addition, make tests and adjustments to ensure efficient and reliable operation of other major components.

38.5 Examine, clean and calibrate as required sensors, thermostats, humidity controls, temperature controls, pressure controls, relays, damper actuators, instrumentation and accessories directly pertaining to the Building Automation System.

38.6 Check and confirm control system sequence of operation to insure optimum system efficiency and economy.

38.7 A log of each loop tested and each control sequence verified shall be reviewed with the owner.

38.8 All components of the Pneumatics Control System will be serviced according to manufacturer's recommendations during each year of the contract. This will include (but not be limited to) all lubricant changes, filter changes, adjustments, calibrations and cleaning.

38.9 The system includes, but is not limited to, the air compressor, air receiver, pressure reducing valves, air dryers and all sensors, controllers, transducers, damper and valve operators, thermostats, pilot positioners, electro-pneumatic switches, linkages and any other pneumatic and electronic devices used to maintain the environmental comfort in the building.

38.10 The Contractor will provide preventative maintenance and diagnostic inspections to all electronic system components on a frequency established by manufacturer's recommendations, component age and condition and discussion with the Supervisor of Operations responsible for the site.

38.11 Provide a fully trained BAS service technician and a Pneumatic fitter (Required for Pneumatic/DDC system) a minimum of one day per month (8 hours for DDC technician and 8 hours for pneumatic fitter) during the warranty period to provide the preventive maintenance and service described above. Provide

written reports to the owner outlining the work performed. Allow for 12 annual visits of one day each (24 days total for 2 years) during the warranty period to provide required service. *(This may change in accordance with the size of the project).*

38.12 Provide emergency service for parts and labor on an as needed basis. Response to an emergency call shall be 2 hours maximum on Mon.-Fri. including on holidays and weekends.

38.13 Provide remote service diagnostic monitoring from the local office. At the request of the owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints.

38.14 Provide a price for a three-year service agreement based on the above requirements to come in to effect upon the completion of the warranty period. Show this price as OPTION: Service Agreement.

PART 2 – OPERATOR WORKSTATION (OWS) AND SOFTWARE

1.0 GENERAL

1.1 General Requirements: Section 23 09 23 BUILDING AUTOMATION SYSTEM (BAS)

1.2 Performance requirements of the Operator WorkStation (OWS) and the Graphical Users Interface are specified in this section.

1.3 Environmental Conditions: The OWS and its immediate associated devices shall be able to operate properly under environmental conditions of 10 deg.C to 32 deg.C and a relative humidity of 20 to 90% non-condensing.

1.4 **OWS shall be provided by the City's IT department.** BAS contractor shall **NOT** include the cost of the computer for the pricing of the project. The OWS shall be provided for centralized system control, information management, alarm management and data base management functions. All real time control functions shall be resident in the standalone Building Control Unit (BC) and local controllers (AACs and ASCs).

1.5 Provide two copies of all Programming Software; one each for OWS and a laptop; **if requirement of a laptop is deemed necessary otherwise provide only one copy. Requirement of a laptop is site specific and shall be provided by the City's IT department. City's project manager shall consult with the district operation manager/supervisor to determine if a laptop is required for the project.**

1.6 Any computer on the BAS LAN shall be capable of displaying the systems in a graphical and dynamic format utilizing a standard web browser. Screen refresh shall be automatic. Manual refresh is not acceptable.

2.0 WORKSTATION HARDWARE REQUIREMENTS

2.1 Reference 1.1.5

2.2 BAS contractor shall coordinate with the City's IT department through the project manager to discuss minimum requirement of the workstation's (computer) hardware, software (operating system) to ensure BAS system will meet or exceed the performance requirement of this specifications.

2.3 Connection to the BAS LAN network shall be via an Ethernet network interface card, 100 Mbps.

2.4 Provide____Workstations. The Workstation(s) will be located as directed by the engineer.

2.5 **This Item is for guidance only.** Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications. Hard disk shall have sufficient memory to store system software, one year of data for trended points specified by the conusltant's sequence of operation and the points list. Workstations shall be with a minimum of:

2.5.1 Intel Pentium 2.66 GHz processor (Pentium IV- Duo Core)

2.5.2 8 GB RAM

2.5.3 100 GB hard disk providing data at 100 MB/sec

2.5.4 48x CD-ROM drive

2.5.5 Keyboard

2.5.6 Mouse

2.5.7 24-inch 24-bit color monitor with at least 1024 x 768 resolution

2.5.8 Serial, parallel, and network communication ports and cables as required for proper system operation

2.5.9 Two (2) USB 2.0 or 3.0 ports

3.0 PRINTERS

3.1 BAS contractor to coordinate with the City's IT department through the project manager to ensure a network printer is connected to the Operator Workstation that is provided by the City's IT department.

3.2 If the site doesn't have a printer available then City's IT department shall provide a desktop printer.

3.3 **Printer Specifications- For Guidance only:** The printer shall be a bubble jet or inkjet printer, 1440 x1440 dpi resolution, internal 1MB buffer memory, minimum 8 ppm in black. No colour printer is required.

4.0 UNINTERRUPTABLE POWER SUPPLIES

4.1 Provide the OWS, Server (if applicable), and each BC with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of at least 15 minutes duration. (site specific)

5.0 PROGRAMMING SOFTWARE

5.1 Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

5.1.1 Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."

5.1.2 Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

5.1.3 Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

5.1.4 Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate

actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

5.1.5 Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

5.1.6 Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

5.1.7 Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

5.1.7.1 Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

5.1.7.2 System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

5.2 The software shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the software shall be through password access as assigned by the system administrator.

5.3 Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

5.4 Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's flywheel effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.

FOR TRIDIUM INTEGRATION (IF APPLICABLE) BAS CONTRACTOR SHALL CONFORM TO ITEMS 5.1, 5.2, 5.3, 5.4 PLUS ITEM 5.5

5.5 A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide real-time data updates. Any real-time data value or object property may be connected to display its current value on a user display.

Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

5.5.1 Programming Methods

5.5.1.1 Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in colour depending on the type of link; i.e., internal, external, hardware, etc.

5.5.1.2 Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

5.5.1.3 The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

5.5.1.4 All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

5.5.1.5 The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

5.5.1.6 The user shall be able to pick a graphical function block from the menu and place on the screen. Programming tools shall place lines connecting appropriate function blocks together automatically. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.

5.5.1.7 The programming tools shall include a test mode. Test mode shall show user real-time data on top of graphical display of selected function blocks. Data shall be updated real-time with no interaction by the user. Function blocks shall be animated to show status of data inputs and outputs. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.

5.5.1.8 Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the contained application that are represented on the graphical shell of this container.

5.6 OPERATOR WORKSTATION SOFTWARE

5.6.1 Operating System: City's IT department will provide OWS including operating system.

5.6.2 The BAS software shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to,

forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.

5.6.3 Real-Time Displays. The OWS, shall at a minimum, support the following graphical features and functions:

5.6.3.1 Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.

5.6.3.2 Graphic screens shall have the capability to contain objects for text, real-time values, animation, colour spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.

5.6.3.3 Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.

5.6.4 Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

5.6.5 Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

5.6.6 Right-clicking the selected object and using a graphical slider to adjust the value shall make adjustments to analog objects, such as set points. No entry of text shall be required.

5.6.7 System Configuration. At a minimum, the OWS shall permit the operator to perform the following tasks, with proper password access:

5.6.7.1 Create, delete or modify control strategies.

5.6.7.2 Add/delete objects to the system.

5.6.7.3 Tune control loops through the adjustment of control loop parameters.

5.6.7.4 Enable or disable control strategies.

5.6.7.5 Generate hard copy records or control strategies on a printer.

5.6.7.6 Select points to be alarm-able and define the alarm state.

5.6.7.7 Select points to be trended over a period of time and initiate the recording of values automatically.

5.6.8 On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.

5.6.9 Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This

auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

5.6.10 System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

5.6.11 Alarm Console. The system shall be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

5.6.12 Operator's workstation software shall contain an easy-to-operate system; allowing configuration of system-wide controllers, including management and display of the controller programming. This system shall provide the capability to configure controller binary and analog inputs/outputs.

5.6.13 The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages. Graphics generation shall be done using standard Windows packages. No proprietary graphics generation software shall be needed.

5.6.14 Provide software, which enables the non-programmer operator to easily perform, tasks which are likely to be part of his daily routine.

5.6.15 The operator's console shall provide facilities for manual entries and visual displays enabling an operator to enter information into the system and obtain displays and logs of system information. All requests for status, analog, graphic displays, logs, and control shall be selected from the operator's console. The operator interface shall minimize the use of typewriter style keyboard by implementing a mouse or similar pointing device and "point and click" approach to command selection. The facility shall be provided to permit the operator to perform the following tasks:

5.6.15.1 Automatic logging of digital alarms and change of status message.

5.6.15.2 Automatic logging of all analog alarms.

5.6.15.3 System changes (alarm limits, set-points, alarm lock-outs, etc.).

5.6.15.4 Display specific points as requested by the operator.

5.6.15.5 Provide reports as requested by the operator and on Scheduled basis where so required.

5.6.15.6 Display graphics as requested by the operator.

5.6.15.7 Display help information.

5.6.15.8 Provide trend logs as required by the operator.

5.6.15.9 Provide manual control of digital and analog outputs as required by the operator.

5.6.15.10 Direct the hard copy output of information to the device selected by the operator.

5.6.15.11 Data displayed on monitor to cyclic update as appropriate.

5.6.16 Online changes:

5.6.16.1 Alarm limits

5.6.16.2 Setpoints

5.6.16.3 Deadbands

5.6.16.4 Changes/deletions/additions of points.

5.6.16.5 Control and change of state changes.

5.6.16.6 Time of day, day, month, year.

5.6.16.7 Control loop control description changes for NCU based CDM's.

5.6.16.8 Control loop tuning changes

5.6.16.9 Schedule changes

5.6.16.10 Changes/additions/deletions to system graphics

5.6.16.11 Changes/additions/deletions to total systems

5.6.17 It shall be possible for the OWS operator to initiate analog and digital output commands. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.

5.6.18 It shall be possible for the OWS operator to place any computed system setpoint to a computed basis or manual value as and when required.

5.6.19 All above functions shall operate under the password protection system.

5.6.20 A vocabulary of at least 25 different descriptions using at least six alphanumeric characters to identify engineering units for analog input and output points. Typical description is as follows: %, Deg.C, KPA, KW, KWH, L/S, CFM, Deg.F, PSI. The descriptions shall be alterable from the OWS console with the system on-line.

5.6.21 Upon operator's request, the system shall present the condition of any single point, any system, and area or the whole system on printer or CRT. The output device shall be by operator's choice. Analog values and status displayed on the CRT shall be updated whenever new values are received. Points in alarm shall be flagged by blinking, inverse video different colour, bracketed, or by some other means to differentiate them from points not in alarm. Overridden (not in auto) points/values shall similarly be identified.

5.7 REPORTING ACCURACY

5.7.1 System shall report values with minimum end-to-end accuracy listed in Table 1.

5.8 CONTROL STABILITY AND ACCURACY

5.8.1 Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1
Reporting Accuracy

Measured Variable	**Reported Accuracy**
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)

Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15ºC (±0.25ºF)
Relative Humidity	±5% RH for monitor only, ±3% RH for control
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm
Note 1: 10% - 100% of scale	
Note 2: For both absolute and differential pressure	
Note 3: Not including utility-supplied meters	

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-50 in. w.g.) differential

5.9 ERROR MESSAGES

5.9.1 Inform operator of all errors in data, errors in entry instructions, failure of equipment to respond to requests or commands, or failure of communications between components of EMCS.

5.9.2 Error messages to be comprehensive and communicate clearly to operator precise nature of problem.

5.10 PASSWORD PROTECTION

5.10.1 Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator's terminal functions unless user is logged on. This includes displays as outlined above.

5.10.2 Each user shall have an individual User ID, User Name and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID shall be 8 characters, User Name shall be 29 characters, and Password shall be 8 characters long. Each system user shall be allowed individual assignment of only those control functions and menu items to which that user requires access. All passwords, user names, and access assignments shall be adjustable online at the operator's terminal. Each user shall also have a set security level, which defines

access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.

5.11 AUDIT LOGS

5.11.1 Provide and maintain an Audit Log that tracks all activities performed on the NCU. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it=s user-defined buffer size. Provide the ability to archive the log locally (to the NCU), to another NCU on the network, or to a server. For each log entry, provide the following data:

5.11.2 Time and date

5.11.3 User ID

5.11.4 Change or activity: i.e., Change setpoint, add or delete objects, commands, etc.

5.12 TREND DATA

5.12.1 System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator's workstation (server) hard disk. Archived files shall be appended with new sample data, allowing samples to be accumulated over several years. Systems that write over archived data shall not be allowed, unless limited file size is specified. Samples may be viewed at the operator's terminal in a trendlog. Logged data shall be stored in spreadsheet format. Operator shall be able to scroll through all trendlog data. System shall automatically open archive files as needed to display archived data when operator scrolls through the data vertically. All trendlog information shall be displayed in standard engineering units.

5.12.2 Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours. Graphs shall show object type value relative to time.

5.12.3 Operator shall be able to change trend log setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.

5.12.4 System shall be capable of periodically gathering energy log data stored in the field equipment and archive the information on the operator workstation's hard disk. Log data shall include both instantaneous and accumulated values. Archive files shall be appended with the new data, allowing data to be accumulated over several years. Systems that write over archived data shall not be allowed unless limited file size is specified. System shall automatically open archive files as needed to display archived data when operator scrolls through the data. Display all energy log information in standard engineering units.

5.12.5 System software shall be provided that is capable of graphing the energy log data. Software shall be capable of creating two-axis (x,y) graph that show recorded data, relative to time. All data shall be stored in comma-delimited file format for direct use by third-party spreadsheet or other database programs. Operation of system shall not be affected by this operation. In other words, it shall stay completely online.

5.12.6 Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. All operations shall be password protected.

5.13 GRAPHICS

5.13.1 The operator's workstation shall display all data associated with the project. The operator's terminal software shall accept Windows BITMAP (*.bmp) format graphic files for display purposes. Graphic files shall be created using scanned, full colour photographs of system

installation, AutoCAD drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator's terminal shall display all data using 3-D graphic representations of all mechanical equipment.

5.13.2 Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 seconds.

5.13.3 Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 seconds and shall automatically refresh every 15 seconds

5.13.4 Colour graphic displays detailing hierarchical structure of facility, including floor plans, with multi-level penetration to equipment level.

5.13.5 System shall be capable of displaying graphic file, text, and dynamic object data together on each display. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc. from any screen no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

5.13.6 All displays shall be generated and customized in such a manner that they fit the project as specified. Canned displays shall not be acceptable. Displays shall use standard English for labelling and readout. Systems requiring factory programming for graphics or DDC logic are specifically prohibited. The installing contractor without factory dependency or assistance shall support all graphics and DDC programming locally.

5.13.7 Binary objects shall be displayed as ON/OFF/NULL or with customized text. Text shall be justified left, right or centre as selected by the user. Also, allow binary objects to be displayed as individual change-of-state bitmap objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three bitmap files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the objects commanded status when the bitmap is selected with the system digitizer (mouse). Similarly, allow the terminal operator to toggle the object's status by selecting (with the mouse) a picture of a switch or light, for example, which then displays a different picture (such as an ON switch or lighted lamp). Additionally, allow binary objects to be displayed as an animated graphic.

5.13.8 Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion. For example: when a pump is in the OFF condition, display a stationary picture of the pump. When the operator selects the pump picture with the mouse, the represented objects status is toggled and the picture of the pumps impeller rotates in a time-based animation. The operator shall be able to click on an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change bitmap file assignment and also create new and original bitmaps online. System shall be supplied with a library of standard bitmaps, which may be used unaltered or modified by the operator. Systems that do not allow customisation or creation of new bitmap objects by the operator (or with third-party software) shall not be allowed.

5.13.9 Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual bitmap items on the display screen as an overlay to the system graphic. Each analog input object may be assigned to a minimum of five bitmap files, each with high/low limits for automatic selection and display of the bitmaps. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the increase or decrease arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trendlogs.

5.13.10 Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value. For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.

5.13.11 A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label push buttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A separate security level may be assigned to each display and system object.

5.13.12 A mouse, or other form of digitizer, shall be used to move the pointer arrow to the desired item for selection of new display or to allow the operator to make changes to object data.

5.13.13 Displays may be modified on site or via remote communications.

5.13.14 Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

5.14 ALARMS

5.14.1 Operator’s terminal shall provide audible, visual, and printed means of alarm indication. The alarm dialog box shall always become the top dialog box regardless of the application(s), currently running (such as a word processor). Printout of alarms shall be sent to the assigned terminal and port.

5.14.2 System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

5.14.3 Alarm messages shall be in user-definable text English (or other specified language) and shall be entered either at the operator’s terminal or via remote communication.

5.15 SCHEDULING

5.15.1 Operator’s terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule. This includes all ON/OFF times (to the minute) for each days events.

5.15.2 Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules. These speciality schedules shall be displayed at the operator’s terminal in a format similar to the weekly schedules, again allowing easy data entry. Exception schedule data is entered by the following methods: date entries (one day entries), date-to-date (a range or span of days), and by weekday (for example, a given day of a given week each month). User shall be able to scroll easily through the months for each year as a minimum.

5.15.3 At the operator’s terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

5.16 ARCHIVING

5.16.1 Store back-up copies of all controllers databases in at least one OWS and/or the server(if applicable).

5.16.2 Provide continuous supervision of integrity of all controller databases. If controller loses database, system to automatically download new copy of database to restore proper operation.

5.16.3 Data base back up and downloading to occur over LAN without operator intervention. Operator to be able to manually download entire controller database or parts thereof.

5.17 REPORTS

5.17.1 Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section. If display output (CRT) is requested, it shall be scrollable; scroll bars will be used to allow easy and flexible movement within the report. Output to be sorted by area, system, point.

5.17.2 Periodic/Automatic Report: Provide the software to automatically generate any report specified, the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device. The software will allow the operator to modify the periodic/automatic reporting profile at any time.

5.17.3 As a minimum, the following reports shall be configured on the system:

5.17.3.1 Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency. It shall be possible to select points on the following basis:

5.17.3.1.1 All points in all areas
5.17.3.1.2 Area (all points in area)
5.17.3.1.3 Area system (all points in system)
5.17.3.1.4 Area system point (individual point)
5.17.3.1.5 System (all points by system and point type)
5.17.3.1.6 System point (all points by system and point type)
5.17.3.1.7 Area point (all points by area and point type).

5.17.3.2 Summary Report: To permit the display or printing the dynamic value for the user specified points which shall indicate the status at the time the CLM was entered. Reports to be available on same basis as dynamic reports. Output will be to the user selected output device.

5.17.3.3 Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.

5.17.3.4 Historical Data Collection: Provision shall be made to ensure historical data is not lost. The ability to off-load historical data to removable media, and to later load data previously backed-up, will be provided. Historical data values, for an operator specified time range and for operator specified points, may be output the same as for trend data.

5.17.3.5 Critical Alarm Summary: Provide a summary of those points in the critical alarm state and include as a minimum; point acronym, point description, alarm type, limit exceed, current value, alarm type, time and date of occurrence.

5.17.3.6 Maintenance Alarm Summary: Provide a summary of those points in maintenance alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceed, time and date of occurrence.

5.17.3.7 Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.

5.17.3.8 Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.

5.17.3.9 Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.

5.17.3.10 Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.

5.17.3.11 User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

5.18 UTILITY SOFTWARE

5.18.1 Supply and install software products to allow the owner to access and manipulate the control schematic diagrams, and to access product data sheets in an electronic format.

5.18.2 Enter all soft copy submissions; including "Record" drawings as specified herein [Shop Drawings, Product Data, etc.] in OWS.

5.19 WEB BROWSER CLIENTS

5.19.1 The system shall be capable of supporting at least 100 simultaneous users using a standard Web browser such as Internet Explorer. Systems requiring additional software to be resident on the client machine to enable a standard Web browser, or manufacturer-specific browsers shall not be acceptable.

5.19.2 The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS, shall not be acceptable.

5.19.3 The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

5.19.4 The Web browser client shall support as a minimum, the following functions:

5.19.4.1 User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

5.19.4.2 Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the Software shall be supported by the Web browser interface.

5.19.4.3 HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.

5.19.4.4 Storage of the graphical screens shall be in the Network Control Unit (NCU), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

5.19.4.5 Real-time values displayed on a Web page shall update automatically without requiring a manual refresh of the Web page.

5.19.5 User's shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

5.19.5.1 Modify common application objects, such as schedules, calendars, and set points in a graphical manner. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.

5.19.5.1.1 Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.

5.19.5.1.2 View logs and charts

5.19.5.1.3 View and acknowledge alarms

5.19.5.1.4 Setup and execute SQL queries on log and archive information

5.19.6 The system shall provide the capability to specify a user's home page (as determined by the log-on user identification). Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.

5.19.7 Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.