University of Toronto – Building Automation Systems

Design Standards and Guidelines

Revision 7

Date: June 21, 2020

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This PDF package contains the following documents:

1. University of Toronto – Building Automation Systems – Design Standards and Guidelines

2. EMRS BACNET Compliance Test Readiness Form.docx

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/EMRS BACnet Compliance Test Readiness Form.docx

3. Wiring Installation Qualification Form.docx

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Wiring Installation Qualification Form.docx

4. DDC and Equipment Power Coordination Schedule.xlsx

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/DDC and Equipment Power coordination schedule.xlsx

5. Project Points List EMRS submittal Form

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Project Points List EMRS Submittal Form.xlsx

The files are embedded in the PDF package.

Document Change Log:

Date	Type of Change	Changed Section	Change Description
17AUG2017	NEW	1.11	Added BAS Sequence of Operations – Context and Format
17AUG2017	NEW	1.11	Added the requirements for the shop drawings submitted by the BAS provider
17AUG2017	MODIFIED	1.1	Modified the intent of the document
17AUG2017	NEW	3.18	Added EMRS Integration with nonBACNET compliant components
17AUG2017	MODIFIED	3.17	Modified the paragraph 3 to mandate the utilization of UofT's Service Tool exclusively
17AUG2017	MODIFIED	2.3.2	Modified the requirements for the BACNET Notification Classes for B-BC
17AUG2017	MODIFIED	2.3.3	Modified the requirements for the BACNET Notification Classes for B-AAC/B-ASC
14SEP2017	NEW	2.3.2	Modified the requirements for the BIBB and mandatory Object Types for B-BC
14SEP2017	NEW	2.3.3	Modified the requirements for the BIBB and mandatory Object Types for B-AAC/B-ASC
14SEP2017	NEW	All	Added the Consultant Compliance pages to the appropriate pages.
01FEB2019	NEW	Multiple	 Added EMRS Commissioning process, Section 3.20 Added Label Requirement to the Section 3.21, Installation Checklist Added As-Built documentation components Replaced "UofT Design Team" for "UofT Project Team" Added section 2.3.3.14 for the AAC/ASC controllers as-built submittal requirements. Added section 3.23 for the report layout definitions for the AAC/ASC TEC MSTP controllers as-built submittal requirements. Total Required Checklist sheets signed by Consulting Agency = 14
01MAY2019	NEW	All	Added the EMRS Bacnet Compliance Test requirements
05AUG2019	NEW	3.2.3, 3.20.4	Merged the UofT BAS Standard document with the Commissioning Process BAS document. New sections created: 3.2.3 and 3.20.4.3.6.1.10
30MAR2020	NEW	3.20.6	The checklist is replaced with the separate document posted directly on the F&S website
30MAR2020	NEW	PART 4	Added PART 4: Document acknowledgement of reading and understanding statements

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Date	Type o Change	Changed Section	Change Description
25JUN2020	NEW	Multiple	 Added the requirement for the DDC and equipment power coordination schedule Added limitation on the number of MSTP devices per B-BC Modified the list of acceptable B-BC devices Modified the Definitions

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BUILDING AUTOMATION SYSTEM (BAS) and EMRS INTEGRATION

PART 1 - INTRODUCTION

1.1 INTENT

1.1.1 The purpose of this standard and design guidelines is to convey the UofT requirements that apply to the Building Automation Systems (BAS) and/or any other mechanical control systems, Direct Digital Controls components, process instrumentation components and the integration with the Energy Management and Reporting System (EMRS).

It outlines the expectations and the bases of design (BOD) for all products, the installations and the quality of the workmanship.

It also outlines the expectations by the Project Consultant and the Commissioning Agent involved in the design phase as the below BAS Standard defines all the information that shall be included in the Design Specification documents.

The report from the sections 3.18 Figures 6 and 7 and 3.19 shall be fully included as the attachment to the Design Specification and it shall be directly referenced to the form part of the Design Specification.

- 1.1.2 This Standard specifies that all BAS on St. George Campus shall be fully interoperable following communication standards based on ANSI/ASHRAE Standard 135-2012 (or current version). Non-BTL listed or legacy BAS are not to be extended or installed. The strategy behind specifying interoperable systems based on BACNET is to:
 - **1.1.2.1** Specify the desired building automation and control system functionality.
 - **1.1.2.2** Specify the desired workstation functionality and relationship to the EMRS.
 - **1.1.2.3** Specify the network technologies, relationships and responsibilities.
 - **1.1.2.4** Specify that all networks shall make use of the BACNET 135 protocol and that all devices supplied shall implement the BACNET functionality as described in the approved device profiles.
 - **1.1.2.5** Specify any additional BACNET functionality as recommended for specific requirements in these Standards.
 - **1.1.2.6** Insure consistent and current BAS designs and installations across the St. George campus portfolio.
 - **1.1.2.7** Engage and expand a centralized enterprise management system for a pan-Campus building performance optimization, verification and reporting system.
 - **1.1.2.8** Provide the management, operations and maintenance teams with the necessary tools to fully manage, operate, expand and

maintain the Campus BAS without using off-campus or software as a service (SaaS) platforms.

- **1.1.3** It is imperative that the University of Toronto procedures defined in this Standard be followed. All requested submissions by the University of Toronto Project Team shall be presented prior to construction for review and sign off. University of Toronto Project Team expects sufficient time to prepare reviews and requires written responses to each point raised by the University of Toronto Project Team.
- **1.1.4** Any references to the obligations of the Contractor in this document shall be incorporated in the Design Specification documentation set provided by the Project Consultant.
- 1.1.5 Throughout this Standard, requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement. Project Consultant may submit products that utilize alternate means, methods, and configurations that meet the functional intent. However, these will only be allowed with prior approval by the University of Toronto Project Team.
- 1.1.6 In these Standards "shall" is used to express a required specification, supplier or criteria that the Project Consultant is obliged to satisfy in order to comply with the Standard. Where no other acceptable manufacturers are indicated, provide as listed in these Standards. Requests for acceptance of alternates must be submitted to and approved by the U of T Project Team before use in the design.
- 1.1.7 Subject to the detailed requirements provided throughout the project specifications, the BAS and digital control and communications components installed shall be an integrated distributed processing system utilizing BACNET communication protocols. System components shall communicate using native BACNET protocols in accordance with ASHRAE Standard 135 and current addenda and annexes.
- **1.1.8** The U of T is interested in state of the art solutions for BAS on Campus. It will not however, allow products or solutions to be tested or beta level equipment to be installed without specific authorization from U of T.
- **1.1.9** A centralized Enterprise Management and Reporting System (EMRS) exist on Campus from which all buildings' BAS can be controlled/monitored. All BAS will require integration to this F&S EMRS.
- **1.1.10** Contractor shall provide all labour, materials, products, equipment and services to supply and install the materials and services indicated on the Drawings and specified in the projects specifications.

The project consultant confirming that all the requirements in the Section 1.1 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 				
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1.2 DESIGN STANDARD OVERVIEW

- 1.2.1 This BAS Design Standard is to be used to define and give guidance to the BAS Project Teams for specifying all BAS and associated components for all BAS new, retrofit, renovation and upgrades at University of Toronto St. George Campus (UofT, UOT, Campus, University).
- 1.2.2 UofT is intent on competitively procuring BAS solutions that cost-effectively provide BAS projects with a complete direct digital control (DDC) building automation system to automatically control the operation of the heating, ventilating, air conditioning and lighting (HVAC&L) systems and monitor and/or control auxiliary systems as applicable to the project scope of work.
- 1.2.3 The Campus architecture is distinguished by building level controls referred to as BAS (and includes controllers, field level devices, actuators, sensors, etc.) and a campus wide enterprise management and reporting system referred to as the EMRS. Any new or migrated BAS shall fully integrate into the EMRS. The required integration shall include the creation and installation of custom interactive color graphics and the compilation and display of all devices and objects from any integrated BAS on Campus. All EMRS graphic displays will reside on the existing EMRS and be developed and modified by UofT F&S IT to suit on a project basis accordingly. The EMRS shall perform the said integration of all BAS on the campus through the use of BACNET/IP communications protocols.
- **1.2.4** A campus wide Ethernet physical layer is supplied and maintained by F&S IT to which all approved IP based devices and systems will connect via a UofT specified and provided color coded patch panels and switches. The BAS Project Consultant shall coordinate with UofT representative for integration and installation of supplied IT components.
- **1.2.5** The Project Architect shall coordinate with the BAS Project Consultant for the location and installation of all IP switches for any given project through the Project Manager.

The project consultant confirming that all the requirements in the Section 1.2 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 				
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1.3 INTEGRATION REQUIREMENTS

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

- 1.3.1 Enterprise Management Level: The main F & S server hosts and maintains the EMRS. The EMRS is at the application layer and provides data sharing, alarm and event management, scheduling, trending and device and network management to approved B-OWS locations. F&S IT manages and defines the architecture and location of the point/object and enterprise databases in the EMRS. The EMRS software resides on the only allowed BAS server for current, proposed and future BAS implementation on Campus.
- **1.3.2** F&S Project Team: Consists of UofT staff and non-staff assigned by UofT to manage the design and implementation of the BAS on any project on Campus. The project manager shall be the main point of contact and coordinate UofT staff for the approvals of the BAS design and implementation.
- 1.3.3 F&S VLAN: A dedicated and secure CAT 6 fiber Ethernet intranet throughout the Campus connecting buildings at a Main Distribution Switch located inside the buildings with a common IP network. The UofT is responsible for the specification, implementation and maintenance of this Campus LAN. All BAS shall connect to this LAN data link layer forming a single campus backbone. Any expansion of this LAN is coordinated with the UofT Central IT department in coordination with F&S IT.
- 1.3.4 Access to the LAN: All access to the Campus LAN (also referred to F&S VLAN) is coordinated and approved with F&S IT who will also control and distribute any required IP addresses and their access timelines. The F&S IT will specify and supply any switches, patch panels and racks or connection devices to the F&S LAN. The Project Consultant shall not design around or install any gateways, Java Application Control Engine (JACE) type of the devices or equivalent, routers, bridges or repeaters without prior approval by U of T Project Team. As soon as the standalone functionalities of B-BC controllers are verified by CxA, the access to the LAN is provided to the BAS vendors. Please refer to the Section 3.20.4.3.6 for any further details.
- 1.3.5 Building level controls: All BAS control devices will connect to the F&S LAN with approved sub-networks. The Standard stipulates that any new or replacement BAS devices will be BACNET Testing Laboratories (BTL) listed with current Protocol Implementation and Conformance Statements (PICS). These include BACNET device profiles B-OWS, B-BC, B-AAC, B-ASC, B-SS and B-SA. The BAS control strategies will reside at the controllers and will communicate with the F&S LAN using MS/TP or IP data link protocols. Other field level network types must be approved by UofT Project Team. BAS technologies that require dedicated servers or gateways in the project will not be allowed without written approval from the UofT Project Team.
- **1.3.6** Field level devices: These include actuators, sensors, valves, etc., that interact with and control the space conditions through the BAS controllers. The specifications for

these devices are found in this Standard. Field level devices typically use the serial field bus RS485 protocol to communicate to the IP based building controller (BC).

- 1.3.7 BACNET object list: BACNET objects associated with a project building controls implementation, with a description of its physical representation, and system association. This document is a critical component of the handover material between a building controls implementation and integration to the EMRS. During BAS design process, a list of BACNET objects, all binary, analog, calculated and virtual points associated with the design and sequences and accessed over the F&S VLAN (not specifically addressed) are required for review by UofT Project Team prior to final project approval. This list will include objects required from embedded controls such as within variable speed drives, chillers, heat pumps and other application specific controllers.
- 1.3.8 Unless otherwise stipulated, the line of demarcation for the BAS contractor is at the patch panel(s) within the building. All control sub network cabling, controllers, end devices and components specified as a part of the BAS are supplied and installed by the BAS contractor. F&S- IT shall coordinate the supply and installation of all F&S Ethernet LAN cabling, switches, racks, patch panels, UPS(s), operator work stations and portable service terminals as required with the BAS contractor.

The project consultant confirming that all the requirements in the Section 1.3 of this document have been incorporated in the project's Design Specification documentation.						
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 						
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1.4 OPTIMUM ENERGY EFFICIENT DESIGN

- **1.4.1** The UofT is committed to efficient, cost effective and sustainable designs for all of its facilities. The BAS design shall present the best use of technologies and sequences of operation for consideration by the UofT Project Team before the final version is submitted for tender or implementation.
- **1.4.2** The BAS shall be capable of implementing the latest in energy conserving sequences of operation such as those described in ASHRAE 90.1 or other industry recognized sequences.
- **1.4.3** The BAS design shall be capable of preparing and presenting performance metrics that illustrate energy use at the BAS and EMRS and/or sharing the data with energy reporting tools as used by UofT.
- **1.4.4** The Consultant will coordinate with the UofT Project Team for the assessment of life cycle costs as associated with energy use and the operation of the BAS.
- **1.4.5** Demand level control shall be the basis of design for HVAC+L control and integrated into the BAS. In particular, the BAS will use actual occupancy loads (people counts) for the control of HVAC+L equipment to minimize overventilation/lighting while still meeting the minimums of ASHRAE 62.1 and 90.1.

1.5 THE CAMPUS AS A "SINGLE BUILDING"

1.5.1 For further clarification of the Campus BAS architecture, the BAS designs, including new, renovations, additions and upgrades, will treat the whole of the Campus as a "single building with multiple mechanical rooms" connected by an existing, F & S LAN through a secure enterprise server where all enterprise management interoperability processes reside, communicating with all the "mechanical rooms" (i.e., buildings, HVAC systems, etc.) BAS connected to the F&S LAN, across the Campus. This "single building" BAS architecture can be imagined as a horizontal version of a 120 storey vertical commercial property with a building wide LAN, central host and floor by floor controller BAS network. The EMRS is the equivalent of a typical tower application layer front end with oversight and access to the complete "building" BAS; the "floors" are similar to the campus buildings with distributed intelligence DDC devices and access for operators and service. The consultants and designers are not to think of any BAS as a "stand-alone" property or project.

1.6 DESCRIPTION OF WORK

- 1.6.1 This standard applies to all BAS projects new buildings, renovations, retrofits, BAS upgrades, new BAS which shall all conform entirely to these BAS Design Standards. Any deviation from these Standards, or the intent, can only be implemented with written approvals from UofT Project Team.
 It is the responsibility of the Project Consultant to ensure that the project design
 - It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:
- **1.6.2** The BAS design will be the result of coordination with and approvals from the U of T Project Team.
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- **1.6.7** Contractor shall furnish and install electronic actuation of dampers and valves to perform control sequences and functions specified. Pneumatic actuation may remain if already in place and F&S Project Team decides to keep that system operational. DDC/pneumatic interface will be the responsibility of the BAS contractor.
- **1.6.8** The distributed DDC and BAS defined in this Standard shall interface with the University F&S Ethernet VLAN.
- **1.6.9** All BAS control work, labor, software, and services including sub-networks and F&S LAN within the building beyond the Main Distribution Switch, shall be installed by the BAS contractor, unless specified otherwise.
- **1.6.10** Systems i.e., chillers, boilers, cooling towers, VFD's and energy recovery units that are equipped with manufacturer furnished controls shall use controllers that follow these Standards.
- **1.6.11** IP enabled control devices are to be provided with static IP addresses supplied by F&S IT.
- **1.6.12** Location of switch(s) and patch panel(s) will be determined during project design with the UofT Project Team. BAS network architecture shall be reviewed by the UofT Project Team prior to acceptance of the design and submission of shop drawings and include all required switch locations, cable needs and connection to the F&S VLAN.
- **1.6.13** All BAS related cabling including sub-networks within the building and VLAN between Main Distribution Switch/Router and switches is the responsibility of the BAS contractor.

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1.6.14 No control devices are to be tied into the F&S VLAN without UofT Project Team approved request protocol. No Ethernet extenders are allowed.

The project consultant confirming that all the requirements in the Section 1.6 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 				
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1.7 OUALITY ASSURANCE

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

- **1.7.1** The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of (3) years since date of final completion in at least [8] installations of comparative size and complexity.
- **1.7.2** No beta level or pilot products with less than 3 years field operation are to be used or tested on Campus without approvals.
- **1.7.3** Applies to Operator Software, Service Tool Software, Controller resident software, B-BCs, B-AACs, B-ASCs, SAs.
- **1.7.4** Documentation of this requirement with references shall be available upon request.
- **1.7.5** All new, retrofit or renovated BAS devices shall meet the most recent BACNET-135 standards and be verifiably BTL listed.
- **1.7.6 Approved manufacturers: Honeywell, Johnson Controls, Siemens**. The approved product lines for the BAS implementations are listed below:

Johnson Controls	Metasys	Supervisory Network Controller
Honeywell	Comfort Point Open	CP-O, CP-IPC, CP400
Siemens	Apogee	PXC Series

JCI Controllers model NAE 55XX are not acceptable.

- 1.7.7 All field level mounted or embedded controllers must be by an approved manufacturer. Any factory level mounted controllers for products such as rooftop units, boilers, chillers, etc., must follow and meet these Standards fully including open point accessibility, device discoverability, readability, write-ability and shall be able to be modified by UofT independently. Proprietary and non-open or otherwise locked systems will not be allowed.
- **1.7.8 Installer's Qualifications**: Firms specializing and experienced in control system installations for not less than **5** years and with experience with proposed DDC technology installation projects with point counts equal to this project and systems of the same complexity and scale as those of the specified project. Experience starts with awarded Final Completion of previous projects. Documentation of this requirement with references shall be available upon request.
- **1.7.9 Installer's Experience with Proposed Product Line**: Firms shall be specialized in and experienced with the installation of the acceptable manufacturers' product line for not less than three years from date of final completion on at least 5 projects of similar size and complexity. Submittals shall document this experience with references.

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- 1.7.10 Installer's Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with control system installation for not less than 5 years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than two (2) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. The proposed individuals must show proof of the following training:
 - **1.7.10.1 Product Line Training**: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on that product line for installation and configuration.
 - **1.7.10.2 Programming Training**: Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the Manufacturer.
- **1.7.11 Installer's Service Qualifications**: The installer must be experienced in control system operation, maintenance and service of the acceptable manufacturers' products. Installer must document a minimum five (5) year history of servicing installations of similar size and complexity. Installer must also document at least a one year history of servicing the proposed product line.

1.7.12 Installer's Response Time and Proximity

- **1.7.12.1** Installer must maintain a fully capable service capacity within a 70 km radius of the project site. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.
- **1.7.12.2** Emergency response times are listed below in this section. Installer must demonstrate the ability to meet the response times.

1.7.13 Installer's Quality Assurance Plan

1.7.13.1 Installer must provide a description of their quality assurance operations from contract award through final delivery. The description shall include organizational responsibilities for each department represented within the execution of this document from installer's to engineers, service technicians and management.

The project consultant confirming that all the requirements in the Section 1.7 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 				
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1.8 SYSTEM ARCHITECTURE

- **1.8.1** The system provided shall incorporate hardware and network resources sufficient to meet the functional requirements of the specified design based on these Standards. The Project Consultant shall be responsible for all items not specifically itemized in these Standards that are necessary to implement, maintain, and operate the system in compliance with the functional intent of the design and these Standards notwithstanding devices that require explicit approvals from UofT Project Team.
- 1.8.2 A system architecture document shall be developed in cooperation with the UofT Project Team that describes graphically the extent of controls installed and their communication hierarchy, from the physical to application (EMRS) layer. All control devices shall be indicated on the floor plans or identified by a room number provided and approved by UofT Project Team.

 F&S network components, including UofT IP switches, shall be shown on the diagram to indicate which equipment is communicating over the F&S network, and indicating its designated static IP address. This document shall be updated throughout the project to track modifications made during design, build out, commissioning and closeout.
- **1.8.3** The system shall be configured as a distributed processing network(s) capable of expansion using the same network technology and BACNET -135 protocols.
- **1.8.4** The system architecture consists of a secure F&S maintained CAT 6 Ethernet-based, Campus local area network (F&S VLAN) connected to all buildings, a single building level or multi-leveled sub-networks (serial field bus, MS/TP, MODBUS) that support BCs, AACs, ASCs, Operator Workstations (OWS), Smart Devices (SD), and portable operator's stations (POTs) as applicable.
- **1.8.5** <left blank.>
- **1.8.6** All connections by IP enabled devices shall be to the F&S network through F&S approved switches. The Project Consultant shall confirm the location and capacity of all switches and shall become aware of where the switches will be located if they are not existing in order to design the sub-networks required.
- **1.8.7** All requests for connections shall be made to Project Consultant at least 3 business days before the connection is required. Any BACNET/IP device shall be specifically configured to use only designated static IP addresses. IP addresses will be issued to contractors for the purposes of BAS installation and commissioning with end dates that will be extended, if requested, through a formal request to F&S IT.
- **1.8.8** The BAS contractor is responsible for supply and installation of all networks from field devices through controllers to the patch panel(s).
- **1.8.9 Remote Data Access**: Design to include remote access connectivity and coordinated with F&S IT. The system shall support the following methods of remote access to the building data through smart phones & portable devices via one or more of the current common standards: Apple iOS (IPhone, IPad), Android Open Source Project

(Android devices), Windows Mobile Devices. Request for Access Form shall be submitted to UofT F&S IT. The form is available here:

http://www.fs.utoronto.ca/wpcontent/uploads/forms/12_BAS_and_EMRS_Access_Process.pdf

- **1.8.10 Browser-based access:** A remote user using a standard browser shall be able access all control system facilities and graphics with proper password. F&S IT shall provide the required internet connection. The following paradigms are acceptable for browser-based access:
 - **1.8.10.1** Native Internet-based user interfaces (HTML, Java, XML, etc.) that do not require a plug-in. The user interface must be compatible with the most current stable version of the supporting software (Java, etc.) without requiring the user to downgrade to a lesser version.
- **1.8.11** The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. The serial field bus, ASC/AAC layout and BC to switch layout is to be planned as necessary to accomplish these performance requirements (maximum values):
 - **1.8.11.1** 3 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
 - **1.8.11.2** 8 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
 - **1.8.11.3** 10 seconds between and a Level 3-5 alarm occurrence and enunciation at operator workstation.
 - **1.8.11.4** 8 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.
 - **1.8.11.5** 3 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
 - **1.8.11.6** 8 seconds between a change of value or state of an input and it being updated on the operator interface.
 - **1.8.11.7** 8 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.
- **1.8.12 EMRS Control Systems Server:** An existing F&S computer (or computers) that maintain the enterprise systems configuration and programming database. The EMRS is at the application layer and provides data sharing, alarm and event management, scheduling, trending and device and network management to approved B-OWS locations.

This server operates virtually under the supervision of F&S - IT. It shall hold the backup and point data files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non-control

- system based programs. It shall allow secure multiple-access to the BAS control information.
- **1.8.13 The EMRS Operator Interface, typically an OWS,** shall provide the overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. The operator interface is the access point to a collection of dynamic displays at the EMRS.
- **1.8.14** EMRS interface type and location to be defined with UofT Project Team. Unless specifically defined otherwise, F&S IT will supply the operator interface(s) in the compliance with the project schedules and timelines.
- **1.8.15** The Temporary Operator Interface Workstation (Temporary GUI): All graphical representations of systems are provided on the temporary vendor specific standalone BAS Workstation with the contractor's temporary installed Graphical User Interface in the building. Provisions of all required alarms, trends, monitoring and control points (physical & virtual) must be provided and verified by the CxA on the Graphical user interface (GUI) provided by the BAS contractor. Screenshots of the GUI pages should be included as a part of the Field Cx Documentation to aid in the development of EMRS
- **1.8.16** Temporary Operator Interface Workstation (Temporary GUI) shall display at a minimum, the information that is embedded within the controls schematics approved by the UofT Project Team. Any modifications during the execution of the project shall be included and part of the interface.
- **1.8.17** The BCs, AACs, ASCs, and SDs shall monitor, control, and provide the field interface for all points specified. Each BC, AAC, or ASC shall be capable of performing all specified energy management functions, and all DDC functions, independent of other BCs, AACs, or ASCs and operator interface devices.
- **1.8.18** Interruptions or fault at any point on the F&S LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.
- **1.8.19** No connections shall be made between fire, life safety, access control systems and the BAS/EMRS unless specifically approved by the UofT Project Team.
- **1.8.20** All line drivers, signal boosters, and signal conditioners etc. if required, shall be approved by UofT Project Team and then provided as necessary for proper data communication. The basis of design does is to not use drivers or boosters but rather through proper network architecture and layout.
- **1.8.21** The BAS vendor must supply its own dedicated temporary communication gateway and/or a modem device for the internet connectivity along with the SMTP service that is properly and securely configured and functional by the BAS vendor. This is to ensure that all the alarms notifications for the predefined and approved critical control objects/points are being sent to the predefined list of the alarm recipients from the Temporary Operator Interface Workstation (Temporary GUI).

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1.9 CODES AND STANDARDS

- **1.9.1** The following codes and standards intended to apply as applicable as not all will apply to all installations. Current and applicable Codes are inserted as required.
- **1.9.2** Comply with rules and regulations of codes and ordinances of local, provincial, and federal authorities; such codes and ordinances, when more restrictive, take precedence over the Contract Documents.
- **1.9.3** It is the intention that all BAS designs and installations provide for optimum operations, monitoring, verification and energy performance. Codes and Standards with a basis of design that encourage optimum long term low energy performance are preferred.
- **1.9.4** American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) 90.1 Energy Standards and 62.1 Ventilation Standards.
- **1.9.5** National Electrical and Local Codes
- **1.9.6** ASHRAE 135-2016: BACNET A Data Communication Protocol for Building Automation and Control Networks. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 2004 including Addendums A through E
- **1.9.7** Federal Communications Commission (FCC) Regulation, Part 15, Subpart J for Class A Computing devices
- **1.9.8** Underwriters Laboratories
 - **1.9.8.1** UL 916: Energy Management Systems.
- **1.9.9** NEMA Compliance
 - **1.9.9.1** NEMA 250: Enclosure for Electrical Equipment
 - **1.9.9.2** NEMA ICS 1: General Standards for Industrial Controls.
- **1.9.10** Institute of Electrical and Electronics Engineers (IEEE)
 - **1.9.10.1** IEEE 802.3: CSMA/CD (Ethernet Based) LAN
- **1.9.11** Refer to University of Toronto Mechanical Design Standards for coordination at: http://www.fs.utoronto.ca/wp-content/uploads/2015/05/Mechanical.pdf
- **1.9.12** Refer to University of Toronto Electrical Design Standards for coordination: http://www.fs.utoronto.ca/wp-content/uploads/2015/05/Electrical.pdf
- **1.9.13** Refer to all the other related standards located here:

https://www.fs.utoronto.ca/DesignStandards/PartOne

https://www.fs.utoronto.ca/DesignStandards/PartTwo

https://www.fs.utoronto.ca/wp-

content/uploads/standards/commissioning/BuildingCommissioningProcess.pdf

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1.10 DEFINITIONS

- **1.10.1 Accuracy**: Accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.
- **1.10.2** Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications. Typically serviced on the serial field bus network.
- **1.10.3 Application Specific Controller (ASC):** A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications. Typically serviced on the serial field bus network.
- **1.10.4 Approvals:** Where ever the term "approvals" or similar is used it shall mean the reference issue must be approved by the UofT Project Team **in writing** before the issue can be incorporated.
- **1.10.5 BACNET/BACNET Standard:** BACNET communication requirements as defined by ASHRAE/ANSI 135-2016.
- **1.10.6 BACNET Interoperability Building Blocks (BIBB):** A BIBB defines a small portion of BACNET functionality that is needed to perform a particular task. BIBBS are combined to build the BACNET functional requirements for a device in a specification.
- **1.10.7 Building Automation System (BAS):** The entire integrated management and control system as applied to a specific project or building.
- 1.10.8 BACNET Building Controller (B-BC): A fully IP programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the F&S LAN and serial field buses, and data storage for trend information, time schedules, and alarm data. A general-purpose device capable of carrying out a variety of building automation and control tasks including control and monitoring via direct digital control (DDC) of specific systems and data storage for trend information, time schedules, and alarm data. Like the other BTL Listed controller types (B-AAC, B-ASC etc.) a B-BC device is required to support the server ("B") side of the ReadProperty and WriteProperty services, but unlike the other controller types it is also required to support the client ("A") side of these services. Communication between controllers requires that one of them support the client side and the other support the server side, so a B-BC is often used when communication between controllers is needed.
- **1.10.9 BACNET Advanced Application Controller (B-AAC):** A control device which contains BIBBs in support of scheduling and alarming but otherwise has limited resources relative to a B-BC. It may be intended for specific applications and supports some degree of programmability.
- **1.10.10 BACNET Application Specific Controller (B-ASC):** A controller with limited resources relative to a B-AAC. It is intended for use in a specific application and supports limited programmability.
- **1.10.11BACNET Instance Numbers:** The BACnet Instance number is a unique number associated with each BACnet object
- **1.10.12BACNET Metafile Definitions:** The precise definition of the constructs and rules needed for creating BACnet objects.

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- **1.10.13 Basis of Design (BOD):** Documentation of the primary thought processes and assumptions behind design decisions that were made to meet the owner's project requirements (OPR). The basis of design describes the systems, components, and methods chosen to meet the OPR.
- **1.10.14 BAS Controller:** A fully programmable device capable of carrying out a number of tasks including controlling and monitoring via direct digital control (DOC) of specific systems, acting as a communications router between the F&S LAN and serial fields busses, and data storage for trend information, time schedules, and alarm data
- **1.10.15 Calibration Tolerance:** The acceptable variation in instrument indication for a given input, for which no adjustment is required. The CTL is derived from the Instrument Manufacturers Limits. The CTL is within the Process Calibration Tolerance Limit of an instrument.
- **1.10.16 Change:** Any addition to, deletion from, or modification to an aspect material, facility, utility, equipment, logic or practice within the scope of the Building Automation System (BAS). This differs from a deviation due to unplanned events requiring temporary actions to be remediated to the initial conditions prior to the unplanned event.
- **1.10.17 Commissioning Authority (CxA):** An individual or company identified by an owner to lead the commissioning activity in the implementation of the Commissioning process.
- **1.10.18 Consultant:** Person(s) responsible for the design of the BAS and retained by and reporting to the UofT Project Team. May consist of the BAS Contractor, M/E consultant, Integrator, UofT Project Team any combination or their assigned representatives. The full scope of the BAS project may be developed by the UofT Project Team or in cooperation with the Consultant.
- **1.10.19 Device Object Identifier:** BACNET can accommodate up to 4,194,305 devices. UofT Project Team will assign Device Object Identifier properties.
- **1.10.20 Direct Digital Control (DDC):** Microprocessor-based control including Analog/Digital conversion and program logic.
- **1.10.21 Embedded Controllers:** Certain equipment contains packaged OEM controllers. These must follow these Standards. Examples can be found in variable speed drives, chillers, boilers, pump sets, etc. In all cases the controllers must be accessible and readable/writable to the BAS and EMRS. Proprietary communication protocols will not be allowed. The integration of the embedded controllers must comply with the Section 3.19 (3EMRS INTEGRATION WITH NON-BACNET COMPLIANT COMPONENTS) of this document.
- **1.10.22 EMRS:** Enterprise Management and Reporting System is a campus wide administration application level system, provided by and maintained by F&S. BACNET interoperability areas data sharing, alarm and event management, scheduling, trending and network management can all be performed at this level. All BAS shall be able to be integrated with the EMRS.
- **1.10.23 EMRS Integration Agent (F&S IT):** Is responsible for performing integration of building controls into the EMRS. This agent may be a third party contractor or U of T's own forces and is responsible for coordinating the BAS/EMRS functionality integration.

1.10.24 Functional Performance Testing: A range of tests under actual load, conducted to verify the specific systems, subsystems, components and interfaces between the systems conform to given criteria.

- **1.10.25 Functional Profile:** A collection of variables required to define the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like. ASC's contain functional profiles.
- **1.10.26 Facility Information Technology (F&S IT):** Reference to the local Information Technology department, responsible for providing and maintaining all Operator Interface hardware and network connections within the facility. Will coordinate with F&S IT for all local IT related efforts.
- **1.10.27 Facilities & Services Project Team (F&S or UofT Project Team):** The Project Team is made up of all or part of the following groups; assigned consultant, F&S IT, Sustainability, Project Manager, Controls Technicians, Area Managers, integrators and any others as assigned by UofT.
- **1.10.28 Facility & Services IT (F&S IT, UofT IT):** Reference to the U of T Facilities & Services Information Technology department responsible for providing and maintaining all F&S LANs, switches, EMRS, integration, IP addresses and access.
- **1.10.29 Gateway:** A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-2004). Gateways are not to be included in the basis for design and must be justified and approved by UofT Project Team before consideration in a final design.
- **1.10.30 Human Machine Interface (HMI):** A device designed to enable humans to access the BAS and /or the EMRS by using a set of custom-built graphics.
- **1.10.31 LAN Interface Device:** Device or function used to facilitate communication and sharing of data throughout the BAS. Includes UofT switches, routers, gateways (if allowed). Typically located in IT rooms, electrical closets, and mechanical rooms. Consultant shall verify locations and include in tender documents. Shall be described, justified and approved by U of T before included in any BAS design.
- **1.10.32 Legacy Systems:** Existing BAS controls systems that are not BTL listed BACNET devices, are no longer supported by the manufacturer, or no longer fit the requirements of U of T's purchasing policy or current design standards, or any combination thereof. Use, expansion of or reuse of any legacy controls systems is not allowed.
- **1.10.33 Local Area Network (LAN):** General term for a network segment within the architecture. In these Standards refers to the F&S Ethernet LAN (UTORNET) connected or to be connected to all buildings on Campus.
- **1.10.34 BACNET MSTP:** Data link protocol as defined by the BACNET standard. Operates over the serial field bus network (RS485).
- **1.10.35 Network Numbering:** BACNET allows for up to 65,535 interconnected networks. UofT Project Team will assign all network numbers.
- **1.10.36 Operational and Maintenance Manual:** A document that describes in lay terms, the operation of all systems and equipment in a facility. An operations manual details modes of operation with associated diagrams to illustrate the sequence of operation for each system and interaction between systems. The maintenance manual describes maintenance requirements and sequences, with the required bill of material.

- **1.10.37 Operational Training:** Training of the individuals who use (owner), operate (facility personnel), or maintain (skilled trades, technicians, and engineers) using current versions of the commissioning documents including operations and maintenance manuals. The training shall be designed specifically for each group delivered both in the classroom and on-site.
- **1.10.38 Operator Interface (OI):** A device used by the operator to manage the BAS including OWSs, POTs, Service Tools
- **1.10.39 Operator Workstation (OWS):** The user's interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications or control to occur. Functionality as defined as a B-OWS in ASHRAE-135. UofT IT specifies and supplies the OWS.
- **1.10.40 Owner's Project Requirement:** A document that provides the explanation of the ideas, concepts, and criteria that are considered very important to the owner. The OPR cites specific measurable goals for the owner's objective.
- **1.10.41 Patch Panel:** A device with a number of ports between field environments and network switches.
- **1.10.42 Portable Operators Terminal (POT):** PC tablet or equal used both for connection to the EMRS. To be supplied by UofT IT. Typically for UofT building operators and controls service technicians. Service level software to be supplied by the BAS contractor. Also referred to as a Service Tool.
- **1.10.43 Process Calibration Tolerance Limits (PCTL):** The maximum allowable deviation of a quality subject to the measurement of the true value before there is an impact on the control of the process.
- **1.10.44 Protocol Implementation Conformance Statement (PICS):** A written document, created by the manufacturer of a device, which identifies the particular options specified by BACNET that are implemented in the device (ASHRAE/ANSI 135-2004).
- **1.10.45 Router:** A device that connects two or more networks at the network layer.
- **1.10.46 Secondary Controlling LAN (Serial field bus):** RS-485 LAN connecting AACs and ASCs.
- **1.10.47 Service Tool:** Laptop PC used by the U of T Control Technicians for servicing all the BAS DDC devices. Specified and supplied by U of T IT.
- **1.10.48 Smart Device/Smart Actuator (SD/SA):** A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.
- **1.10.49 Static Verification:** The verification and documentation that all system elements are in accordance with the design requirements, correctly installed, connected and labeled with consideration for accessibility.
- **1.10.50 Startup Verification:** The verification that documentation is complete, sensors are calibrated, control wiring integrity checked, correct response of all points in the system verified with the correct response from all end devices.
- **1.10.51 System Graphics Screens:** EMRS Built-in Graphic User Interface that provides the basic information on the BAS and/or EMRS related to any particular BAS data object for the commissioning task only
- **1.10.52 Switch:** A device that filters and forwards packets between LAN segments, in this case, between the field level network and the F&S LAN. UofT IT specifies and

supplies the switches and associated patch panels in coordination with the UofT Project Team and the BAS contractor.

1.10.53 University of Toronto (UofT): Owner of the facility. In terms of these Standards, represented by the UofT Project Team.

1.11 SUBMITTALS – DOCUMENTS, SHOP DRAWINGS, SEQUENCE OF OPERATIONS

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

1.11.1 During the design phase and prior, the project tender, the Project Consultant shall provide the complete project documentation, including the sequence of operations, the equipment and BAS panel coordination power schedule (see section (1.11.13) along with the high level controls architecture diagram for the UofT Project Team to review and the final acceptance.

The equipment and BAS panel coordination power schedule is located under the PDF Attachments.

Within 30 days of award of contract, before start of construction, BAS Project Consultant submits completely engineered and coordinated shop drawing package.

- **1.11.2 Electronic Submittals**: Four (4) copies of the Control submittals and O&M information shall be provided in unlocked, editable Adobe PDF or Microsoft Word format. Documents will be converted from their native electronic format directly to a preferred format. Any documents scanned as images must be converted to a searchable text format using OCR (Optical Character Recognition) and reduced in size prior to submission.
- **1.11.3 Qualifications**: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate item above. Include QA/QC plan for all phases (design, install, Cx, warranty, training) along with documentation of industry standard QA/QC practices followed.
- **1.11.4 Product Data:** Submit four (4) copies of the manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.
- **1.11.5 Shop Drawings**: Submit four (4) copies of the shop drawings for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall contain the following information:
 - 1.11.5.1 One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, etc. Indicate network number, device ID, drawing reference number, and controller type for each control unit. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.
 - **1.11.5.2** Indicate device instance and IP address for each controller. Indicate media, protocol, baud rate, and type of each LAN.
 - **1.11.5.3** Provide floor plans on Adobe PDF software locating all control units, LAN interface devices, etc. Include all LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Wiring routing as-built conditions shall be maintained accurately throughout the

- construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
- **1.11.5.4** Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each network. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans.
- **1.11.5.5** Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include verbal description of sequence of operation.
- **1.11.5.6** Sequence of Operation: Provide description of operation for interlocks that directly connect to the Work. Indicate references to the system flow diagram by control device designation or point object name.
- **1.11.5.7** All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
- **1.11.5.8** With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number).
- **1.11.5.9** Submitted drawings to include labels for each control device with setting and adjustable range of control and units.
- **1.11.5.10** Submitted drawings to include labels for each input and output with the appropriate range and units.
- **1.11.5.11** The BAS vendor shall be instructed within the Design Specification to include any relevant information from the others that the BAS system will be integrated directly to EMRS.
- **1.11.6** Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
- **1.11.7** Provide a Control Valve Schedule listing valve and actuator information including: size, C_v, design flow, design pressure drop, manufacturer, model number, close off rating, control signal, etc. Indicate normal positions of spring return valves.
- **1.11.8** Provide a Control Damper Schedule listing damper and actuator information including: size, material, blade arrangement, manufacturer, model number, control signal, etc. Indicate normal positions of spring return dampers.
- 1.11.9 Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified, connections between control devices, controllers and equipment; connections to sources of power and grounds; control device designations, control device terminal designations, control device location; equipment terminal designations; cabinet terminal strip designations; wire

designations. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring which are existing, factory-installed and portions to be field-installed. For control devices shown on multiple drawings, indicate the control device with the same designation on all drawings. Differentiate between manufacturer installed wire and field installed wire.

- **1.11.10** Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations. Provide panel layout drawing including power supply, control unit(s) and wiring terminals.
 - **1.11.10.1** Sheets shall be consecutively numbered.
 - **1.11.10.2** Each sheet shall have a title indicating the type of information included and the HVAC+L system controlled.
 - **1.11.10.3** Table of Contents listing sheet titles and sheet numbers.
 - **1.11.10.4** Provide a symbol legend and list of abbreviations.
 - **1.11.10.5** All field labeling of devices must match the device identifications listed in the Control schematic. Submit a sample of labeling to be used.

1.11.11 Control Logic Documentation and Software

- **1.11.11.1** Submit control logic program listings to document the control software of all control units to the UofT Project Team.
- **1.11.11.2** Include written description of each control sequence.
- **1.11.11.3** Include test plan for each unique control program.
- **1.11.11.4** Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.

1.11.12 Operation and Maintenance Materials:

- **1.11.12.1** Documents shall be provided electronically as described above (**Section 1.11.2**). **Submit four (4) copies.**
- **1.11.12.2** Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessories.
- 1.11.12.3 Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1. Only include sections for equipment and software used on this project. Do not provide entire catalog of product data with extraneous information.
- **1.11.12.4** Submit BAS User's Guides (Operating and Service Manuals) for each controller type to the UofT Project Team.
- **1.11.12.5** Submit BAS Advanced Programming Manuals for each controller type to the UofT Project Team.
- **1.11.12.6** Controls contractor shall provide UofT Project Team with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches throughout the warranty period of the project.
- **1.11.12.7** Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance to the UofT Project Team

1.11.12.8 Product Warranty Certificates: UofT Project Team shall approve all warranty start dates.

1.11.12.9 Coordinate and submit manufacturers product warranty certificates covering the hardware provided once approved by the UofT Project Team.

1.11.13 BAS Sequence of Operations – Context and Format

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below:

1.11.13.1 PURPOSE

Purpose of this standard is to convey minimum University of Toronto, Facilities and Services expectations in terms of the context and format of the Sequence of Operation for Building Automation System (BAS) for the Project Consultant to include in the Design Specification It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

1.11.13.2 INTENT

Clear, detailed control sequence of operation is necessary to provide proper operation of the building. It shall sufficiently describe in simple and understandable language how the control system and associated building systems and equipment shall operate. Energy consumption, savings and demand as well as system performance troubleshooting are also part of the building operation and BAS.

The sequence of operation shall provide a story of the design intent for the building operation with set values to what the building shall be operated to (set points). It shall clearly state what parameters shall be adjusted / determined during initial start-up, balancing, commissioning and what are user adjustable. It shall provide information on safety features (hardwired / soft points), integration with life safety systems (fire alarm, smoke exhaust, stair pressurization, and similar). It shall describe system operation during power failure, scheduled start / stop and integration with any other building systems / equipment.

BAS vendor is a controls integrator so the BAS shop drawings and sequence of operation have to have all required details to allow the UofT Facilities and Services to operate and maintain the buildings, which means that all relevant info associated with packaged units and lab controls has to be included in and/or clearly referenced & affixed as appendices with this document. These mandatory requirements are applicable to all the projects listed in the section 1.2 of this document.

1.11.13.3 APPLICATION

This Standard is applicable for BAS controls and any other control systems that may be provided by the separate control vendors / equipment packages for integration with / through BAS system. Examples are Lab control, Fume Hood control, VRF systems, packaged AHUs, chillers, boilers, VRF systems, etc.

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1.11.13.4 BAS SEQUENCE OF OPERATIONS - CONTENT

The sequence of operation shall consist as a minimum of following sections. The consultant shall provide as many sections as required and details as required to meet the intent of this Standard.

- a) system general description of the system (what is it serving, components, locations, integration with any other systems / equipment),
- b) schedule,
- c) start/stop,
- d) safeties (hardwired connections, integration with life safety systems fire alarm and similar) if applicable
- e) modes of operation (occupied / uncopied) and control (temperature control, etc.),
- f) list of all points that shall be alarmed,
- g) list of all points that shall be monitored,
- h) list of all points that shall be historically gathered for trend creation, and any pre-set trends that can be created to help in troubleshooting / monitoring system operation.
- i) list of all setpoints that shall be adjusted the Design Specification shall indicate on the controls as-builts drawings the list of adjustable setpoints that have been set/adjusted/modified during the commissioning and verification.
- j) any special requirements for graphical user interface.
- Set up of the points that shall be historically gathered and trended, as well as graphical user interface will be done during EMRS integration phase by UofT resources. They shall be included in the Shop Drawings Sequence of Operation document for information purposes. Consultant shall propose preset trends that will help with troubleshooting purposes that can be determined during commissioning process and added to as —built Controls Shop drawings.
- k) Details for Sequence of operation as listed in the points a) to e), points & graphical representation as listed in f) to i), & instruments (details associated with maintenance & operations) for packaged units / controls (as listed in the section 1.11.13.3 of this document) have to be also included in BAS control package.

The integration between BAS and packaged unit, the scope of the integration and the scope of the autonomous control shall be clearly indicated and defined.

1.11.13.4.1 General Description

The overview of the system or purpose of the equipment; what equipment is controlled and where the equipment located; any interactions with other systems; overview is how each component will work together as a system; etc.

1.11.13.4.2 Schedule

Scheduled run conditions during occupied and unoccupied modes.

1.11.13.4.3 System Start/Stop

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Description of the how each component on the system will operate, including start-up and shutdown; enable/disabled.

Sequence of events in case the equipment fails to start and/or in emergency situation.

1.11.13.4.4 System Start/Stop

Description of the how each component on the system will operate, including start-up and shutdown; enable/disabled.

Sequence of events in case the equipment fails to start and/or in emergency situation.

Sequence of events in case of the power outage: operation during power outage and/or start upon restoring of normal power.

1.11.13.4.5 Safeties

List of failure modes and safety devices or subsystems, safety hardwires / soft points and interconnection with fire / life safety system.

1.11.13.4.6 Mode of operation and control strategies/sequences

System / equipment specific sequence description detailing process, sequence of events and parameters with all set point based on the time of day schedule and/or season (heating, cooling, economizer mode).

Detail description of the process and sequence of events with breakdown per component / equipment when multiple components / equipment is required to operate to control / maintain one parameter. For example: temperature control in VAV system where terminal units have reheat coils, or in central VAV system where one VAV air handling unit is serving one space.

Control strategies for control of various parameters (temperature, air flow, pressurization, etc.)

Parameters used for:

- a) Setback control (such as temperature set point unoccupied / occupied mode),
- b) Reset control (such as hot water heating temperature reset based on the outside temperature),
- c) Low limit / high limit control (such as low limit for mix –air damper control or high limit for a maximum temperature or relative humidity),
- d) Lead(duty) / Stand-by control (such as run time to alternate two pumps in a system where one pump is duty and the one is stand-by),
- e) Lead / lag control (such as staging up / down pumps to meet load and alternating them based on the runtime),
- f) High/Low signal select control (for example when a space has a multiple sensors and one control)
- g) Return fan control (for example modulating the speed of the return fan to maintain pressurization needs to be based on the volumetric offset shall be detailed in either written or tabulated form, with exact values.

The setpoints shall be defined with the ranges that can be adjusted but will not adversely affect the system operation. The setpoints tolerances shall also be included.

If the values are to be adjusted by operator through the EMRS (BAS) interface, it shall state "operator adjustable".

If the values are to be adjusted during commissioning, it shall state "adjustable".

If the values are to be adjusted by the building occupants via a user interface (such as Adjustable Room Thermostats or similar), it shall state "user adjustable".

The expected priority and the setpoint adjustment arbitration "operator" versus "occupant" shall be clearly defined and stated.

1.11.13.4.7 Data Collections and Historical Trends

List all the points that shall be collected and at what duration.

Indicate what trends shall be pre-set.

a. Troubleshooting

List out possible troubleshooting process and provide pre-set trends.

b. Energy monitoring

Outline energy savings & consumption monitoring features.

Provide calculations that shall be used by the BAS controls vendors for the output values such as:

Flow

Consumption

Supply and Return Temperature

Differential, Supply and Return Pressure

Energy Flow Calculation

1.11.13.4.8 EMRS Graphical User Interface

Identify any special parameters that shall be included on the graphical interface (such as energy savings on the equipment with heat recovery components and/or free cooling, waste heat, pressurization diagrams). Refer to the Section 3.15 and 3.22 for more details.

1.11.13.4.9 Alarms

List all the mandatory process values that shall be included in the DDC Alarm Notifications with the clear identification of the low and high alarm limits.

Layout all the alarms in the table format to include the following:

Alarm Description of the even causing the alarm,

Action that should be taken and classification of the alarm.

Example – for reference of the Alarm table intent and format only as follows:

heating loop - example

Alarm Description	Action	Alarm
lead pump commanded on and pump does not start (5 min delay)	start second Pump	high
Both pump fail to start	Shut down	Critical
Low supply water temperature (10 °C below SP for 10 mn)	Continue to run	Critical
Pump status On / Commanded OFF	Pump to remain off	Low
system in Manual	indicate on Graphic	Low

Provide the list of all the necessary documents (ex.: floor plans, zoning diagrams, etc.) to create the graphical interface with the visual indication of the alarm state for each process value.

1.11.13.5 Summary Checklist – to be populated by the consultant during the design stage

design stage	
	Included in the Consultant BAS
	Specification (YES /
Sequence of Operation / Shop drawings	NO / N/A)
a) system general description of the system (what is it serving, components, locations, integration with any other systems / equipment)	
b) schedule	
c) start/stop	
d) safeties (hardwired connections, integration with life safety systems – fire alarm and similar) – if applicable	
e) modes of operation (occupied / uncopied) and control (temperature control, etc)	
f) list of all points that shall be alarmed	
g) list of all points that shall be monitored	
h) list of all points that shall be historically gathered for trend creation, and any pre-set trends that can be created to help in troubleshooting / monitoring system operation.	
i) list of all setpoints that shall be adjusted	
j) any special requirements for graphical user interface	
k) Details for Sequence of operation as listed in the points a) to e), points & graphical representation as listed in f) to j), & instruments (details associated with maintenance & operations) for packaged units / controls (such as Lab & Fume Hood controllers) also has to be also included in BAS control package. The integration between BAS and packaged unit, what can be done via BAS (control and/or monitor) and what controls will be done via packaged unit has to be clear indicated and delineated	
	Included in the Consultant BAS Specification (YES /
Documents	NO / N/A)
a) Zoning Diagrams	
b) Control Schematics	
c) Air Pressurization Diagrams	

University of Toronto

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List of Packaged units / control systems that are to be integrated via BAS with EMRS (Consultants to populate)	Included in the Consultant BAS Specification (YES / NO / N/A)	Local controls with display provided (YES/NO/N/A)
1		
2		
3		
4		
5		

The project consultant confirming that all the requirements in the Section 1.11 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 				
Provide the explanation, if NO or N/A options are selected:				
The project consultant to provide the cross-re- Automation and Energy Systems Design Standard	eference between the sections in the Building and the Project Design Specification:			
Building Automation and Energy Systems Design Standard	Project Design Specification			
Ex. 2.3	22.13			
	<u> </u>			
CHECKLIST 6 Date: Consulting Engineer:	Signature:			
Consulting Engineer.	Signature.			

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1.12 PROJECT RECORD DOCUMENTS:

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

- **1.12.1** Documentation shall be provided electronically as defined in (see Section 1.11.2).
- **1.12.2** Record copies of product data and control shop drawings updated to reflect the final installed condition. **Submit four (4) copies.**
- **1.12.3** Record copies of approved control logic programming and database on CD/DVD or USB key.
- **1.12.4** Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.
- **1.12.5** "As-built" record drawings that represent the final system architecture, configuration input/output points and device locations in the AutoCAD Editable format.
- **1.12.6** I/O points list shall include the name/description, display units, alarm limit(s)/definitions and BACNET object description, including Object ID and Device ID, for each I/O point.
- **1.12.7** Record copies of approved project specific graphic software on CD/DVD or USB key.
- **1.12.8** Record copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring.
- **1.12.9** Documentation for any non-standard BACNET objects, properties, or enumerations used detailing their structure, data types and any associated lists of enumerated values.
- **1.12.10** Integration details with any BACNET based control systems (i.e., lighting, chemical treatment, thermal occupancy counting sensors, wireless controls.).
- **1.12.11** Provide record riser diagram showing the location of all controllers, connection to F & S switches, routers, wireless and repeaters.

The project consultant confirming that all the requirements in the Section 1.12 of this document have been incorporated in the project's Design Specification documentation.				
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. 				
\square N/A , the requirements in this section are not ap	opincable for the project the DS.			
Provide the explanation, if NO or N/A options are	re selected:			
	eference between the sections in the Building			
Automation and Energy Systems Design Standard Building Automation and Energy Systems				
Design Standard	Troject Design Specification			
Ex. 2.3	22.13			
	<u></u>			
CHECKLIST 7				
Date: Consulting Engineer:	Signature:			

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1.13 WARRANTY MAINTENANCE

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

- **1.13.1** BAS Contractor shall warrant all products, software and labor for specified control system free from defects for a period of two (2) years after Final Acceptance by UofT Project Team. Provide unit pricing for additional warranty years at discretion of UofT Project Team.
- **1.13.2** Work shall have a single warranty date, even if U of T Project Team receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
- 1.13.3 The University of Toronto reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Project Consultant shall warrant parts and installation work regardless of any such changes made by the UofT, unless the Project Consultant provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between the University and the Project Consultant on such matters shall be subject to resolution through the contract 'Disputes' clause.
- **1.13.4** At no cost to the UofT, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:
 - **1.13.4.1 Maintenance Services:** Shall be provided for all devices and hardware specified for the project. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.
 - **1.13.4.2 Emergency Service:** Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the University to the Contractor.
 - **1.13.4.2.1** Response by telephone to any request for service shall be provided within one (1) hour of the University's initial telephone request for service.
 - 1.13.4.2.2 In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within two (2) hours of the University's initial telephone request for such services, as specified.
 - **1.13.4.3 Normal Service:** Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the University to the Contractor.
 - 1.13.4.3.1 Response by telephone to any request for service shall be provided within **two** (2) working hours (contractor specified 40 hr. per week normal working period) of the University's initial telephone request for service.

- 1.13.4.3.2 In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within **three** (3) working days of the University's initial telephone request for such services, as specified.
- **1.13.4.4 Request for Service:** BAS Contractor shall specify a maximum of three (3) telephone numbers for UofT Project Team to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. Once contacted a technician shall respond to every call within 15 minutes.
- **1.13.4.5 Technical Support:** Contractor shall provide technical support to UofT Project Team throughout the warranty period.
- **1.13.4.6 Preventive Maintenance:** Shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.
- **1.13.4.7** All warranty work to be performed by original manufacturer trained staff.
- **1.13.4.8** Provide updates to controller firmware that resolve Contractor identified deficiencies at no charge during warranty period.
- **1.13.4.9** Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Project Team's acceptance.
- **1.13.4.10** Factory mounted controllers shall be warranted by the manufacturer, not the controls supplier.

The project consultant confirming that all the requirements in the Section 1.13 of this document have been incorporated in the project's Design Specification documentation.					
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 					
Provide the explanation, if NO or N/A options are	re selected:				
The project consultant to provide the cross-re Automation and Energy Systems Design Standard	eference between the sections in the Building I and the Project Design Specification:				
Building Automation and Energy Systems					
Design Standard Ex. 2.3	22.13				
CHECKLIST 8 Date: Consulting Engineer:	Signature:				

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1.14 DELIVERY, STORAGE, AND HANDLING

It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

- **1.14.1** Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from construction work and weather.
- **1.14.2** Contractors and any trades associated with the project are responsible for transportation required to get to and from the project site.
- **1.14.3** Left <blank>
- **1.14.4** Contractors must coordinate with UofT Project Team for the use of any space on Campus for material storage and will do so at their own risk.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- **2.1.1** Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.
- **2.1.2** Prototype or beta products are not to be used in designs or installations unless approved by UofT.

2.2 UNIFORMITY

- **2.2.1** All equipment of the same type serving the same function shall be identical and from the same manufacturer.
- **2.2.2** All naming conventions and graphics shall be consistent for all projects according to these Standards.
- **2.2.3** UofT Project Team will review and confirm the systems, nomenclature and graphics as uniform before accepting the final design. See Section 3.17 Fig. 1 5 for example graphic and Fig 7 for sample point naming.

2.3 BAS FIELD DEVICES AND INSTRUMENTATION

2.3.1 STAND-ALONE FUNCTIONALITY

- **2.3.1.1 General**: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category. This item refers to acceptable paradigms for associating the points with the controller(s).
- **2.3.1.2 Functional Boundary**: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.
- **2.3.1.3** The following configurations are considered acceptable with reference to a controller's standalone functionality:
 - **2.3.1.3.1** Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
 - **2.3.1.3.2** Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
 - **2.3.1.3.3** I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
 - **2.3.1.3.4** I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller

and that communicate via an approved subnet protocol. These arrangements to be considered standalone shall have a subnet LAN that is dedicated to that controller and include no other controller devices (AACs or ASCs). All wiring to interconnect the I/O expander board shall be:

- a) Contained in the control panel enclosure
- b) Or run in conduit. Wiring shall only be accessible at the terminations.

2.3.2 BACNET Building Controller (B-BC)

- **2.3.2.1** The BC(s) shall provide fully distributed control independent of the operational status of the EMRS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
- 2.3.2.2 BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the F&S LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
- **2.3.2.3** BCs will be used in each equipment room where major or more than two pieces of equipment are being controlled. The use of ASC or AAC devices for critical or main system equipment will not be permitted.
- **2.3.2.4** All BCs that are configured as the BBMD shall be labeled as "BAS Broadcast Device". Any BC set up as a BBMD shall be installed in a separate locked and labeled NEMA 4 enclosure and be powered through a lockable circuit breaker.
- **2.3.2.5** For broadcast distribution, BBMD's shall be provided or appropriate arrangements made for the use of IP multicasting.
- **2.3.2.6** BCs shall be programmable from Service Tool.
- **2.3.2.7** BCs shall be connected to the F&S LAN through color coded patch panels and switches specified and supplied by F&S IT. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:
 - **2.3.2.7.1** Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.
 - **2.3.2.7.2** EEPROM, EPROM, or NOVROM non-volatile memory.
 - **2.3.2.7.3** Dedicated UPS.

- **2.3.2.8** In addition BCs may provide intelligent, standalone control of HVAC functions. Each BC may be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices.
- **2.3.2.9** The BC shall provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Shall have a minimum of 10% spare (panel real estate) capacity for future point connection and no less than two (2) spares of each implemented I/O type.
- **2.3.2.10** All BC point data, algorithms and application software shall be modifiable from the Service Tool.
- **2.3.2.11** Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the Service Tool.
- **2.3.2.12** BC shall provide buffer for holding alarms, messages, trends etc.
- **2.3.2.13** Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
- **2.3.2.14** The following is the list of the mandatory Bacnet Interoperability Building Blocks (BIBBs) for the B-BC:
 - **2.3.2.14.1** Alarm and Event Services:
 - **2.3.2.14.1.1** Alarm and Event Notification Acknowledgement: AE-ACK-A; AE-ACK-B
 - **2.3.2.14.1.2** Alarm and Event Alarm Summary: AE-ASUM-A; AE-ASUM-B
 - **2.3.2.14.1.3** Alarm and Event Notification: AE-N-A
 - **2.3.2.14.1.4** Subscribe COV: DS-COV-A; DS-COV-B
 - **2.3.2.14.2** Data Sharing:
 - **2.3.2.14.2.1** Read Property: DS-RP-A; DS-RP-B
 - **2.3.2.14.2.2** Read Property Multiple: DS-RPM-A; DS-RPM-B
 - **2.3.2.14.2.3** Write Property: DS-WP-A; DS-WP-B
 - **2.3.2.14.2.4** Write Property Multiple: DS-WPM-A; DS-WPM-B
 - **2.3.2.14.3** Device and Network Management:
 - **2.3.2.14.3.1** Dynamic Device Binding: DM-DDB-A; DM-DDB-B
 - **2.3.2.14.3.2** Dynamic Object Binding: DM-DOB-A; DM-DOB-B
 - **2.3.2.14.3.3** Time Synchronization: DM-TS-A; DM-TS-B
 - **2.3.2.14.3.4** UTC Time Synchronization: DM-UTC-A; DM-UTC-B
- **2.3.2.15** The following is the list of the mandatory Bacnet Object Types for the B-BC:
 - **2.3.2.15.1** Analog Input
 - **2.3.2.15.2** Analog Output
 - **2.3.2.15.3** Analog Value
 - **2.3.2.15.4** Binary Input
 - **2.3.2.15.5** Binary Output

- **2.3.2.15.6** Binary Value
- **2.3.2.15.7** Multistate Value
- **2.3.2.15.8** Notification Class
- **2.3.2.15.9** Calendar
- **2.3.2.15.10** Schedule
- **2.3.2.16** Three (3) mandatory BACNET Alarm Notification classes must be created in every B-BC with the following definitions:
 - 2.3.2.16.1 Notification Class URGENT Bacnet Priority 80
 - **2.3.2.16.2** Notification Class HIGH Bacnet Priority 160
 - **2.3.2.16.3** Notification Class LOW Bacnet Priority 240

All the Notification Classes shall allow to modify the Priorities through EMRS.

The Notification Class object name must comply with the following naming convention:

xxx_DDCyy_NCz_URGENT - for Urgent priority

xxx_DDCyy_NCz_HIGH – for High priority

xxx_DDCyy_NCz_LOW – for Low priority

where:

xxx – building number

yy – controller index

z – Notification Class index

All process values shall be assigned to the Notification Class LOW priority by default.

UofT Project Team will reassign the priorities for the process values based on the internal process.

- **2.3.2.17** B-BC functionality and compliance with BIBB and Object Types shall be presented to the U of T Project Team before shop drawing submission. Functionality must be approved by the U of T Project Team.
- **2.3.2.18** B-BC shall be BTL listed.
- **2.3.2.19** Each BC shall contain software to perform full DDC/PID control loops.

2.3.2.20 Input-Output Processing:

- **2.3.2.20.1 Digital Outputs (DO):** Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and a manual hand-off -auto switch to allow for override. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
- **2.3.2.20.2 Analog Inputs** (**AI**): AI shall be 0-5 VDC, 0-10 VDC, and 4-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's

board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D

2.3.2.20.3 <u>Digital Inputs (DI):</u> Monitor dry contact closures. Accept pulsed inputs of at minimum one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.

converters shall have a minimum resolution of 12 bits.

- **2.3.2.20.4** <u>Universal Inputs (UI-AI or DI)</u>: To serve as either AI or DI as specified above.
- **2.3.2.20.5** Electronic Analog Outputs (AO): Voltage mode: 0-5 VDC and 0-10 VDC; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection.
- **2.3.2.20.6** <u>Pulsed Inputs</u>: Capable of counting up to 10 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.
- **2.3.2.21** A communication port for Service Tool shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port.
- **2.3.2.22** Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Service Tool software is acceptable. Tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
- **2.3.2.23** All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.

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2.3.2.24 Every Analog Input and Analog Output point must have the Bacnet Change of Value Increment (COV) parameters configured as per the table below:

	Space	Return Air	Discharge Air	Mixed Air	Outside Air	Chilled Water	Hot Water	Cond. Water
Temperature (°F or °C)	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5
Pressure								
INW	0.01	0.1	0.1					
PSI						0.5	0.5	
Humidity	2	2	2	5	2			
Volumetric Flow	5% of setpoint	2% of setpoint	2% of setpoint			2% of setpoint	2% of setpoint	2% of setpoint
	All types							
Outputs	5% of range							

	All types
Outputs	5% of range

2.3.2.25 BC Power Loss:

- 2.3.2.25.1 Upon a loss of power to any BC, the other units on the F&S LAN shall not in any way be affected.
- **2.3.2.25.2** Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the DDC software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. An alarm diagnostic message shall indicate that the BC is under battery power.
- **2.3.2.25.3** Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
- 2.3.2.25.4 Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via Service Tool. In addition, the University shall be able to upload the most current versions of all energy management control programs, DDC programs, database parameters, and all other data and programs in the memory of each BC via the Service Tool.

2.3.2.26 BC Failure:

2.3.2.26.1 F & S LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss and report a critical level alarm.

- **2.3.2.26.2 BC Hardware Failure:** BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.
- **2.3.2.27** Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.)
- **2.3.2.28** BCs may include LAN communications interface functions for controlling serial field bus sub-networks.

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2.3.3 BACNET Advanced Application Controller (B-AAC) and Application Specific Controller (B-ASC)

- **2.3.3.1** Where these devices are included with HVAC+L equipment such as boilers, chillers, variable speed drives, lighting, pump sets, air handling units, etc., they shall meet these Standards. In particular they shall be able to be connected to the EMRS using BACNET communication and interoperability protocols with complete accessibility to objects/points in the controller.
- **2.3.3.2** AACs and ASCs shall provide intelligent, standalone control of HVAC+L equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the ASC sub-network. It shall be able to share information with every other BC and AAC/ASC on the entire network.
- **2.3.3.3** Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the related BC, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
- **2.3.3.4** AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
- **2.3.3.5** Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty (50) hrs with a minimum battery life of five (5) years.
- **2.3.3.6** All point data, algorithms and application software within an AAC /ASC shall be modifiable from the Service Tool.
- **2.3.3.7** The following is the list of the mandatory Bacnet Interoperability Building Blocks (BIBBs) for the B-AAC and B-ASC:
 - **2.3.3.7.1** Alarm and Event Services:
 - **2.3.3.7.1.1** Alarm and Event Notification Acknowledgement: AE-ACK-A; AE-ACK-B
 - **2.3.3.7.1.2** Alarm and Event Alarm Summary: AE-ASUM-A; AE-ASUM-B
 - 2.3.3.7.1.3 Alarm and Event Notification: AE-N-A
 - **2.3.3.7.2** Data Sharing:
 - 2.3.3.7.2.1 Read Property: DS-RP-A; DS-RP-B
 - 2.3.3.7.2.2 Read Property Multiple: DS-RPM-A; DS-RPM-B
 - 2.3.3.7.2.3 Write Property: DS-WP-A; DS-WP-B
 - 2.3.3.7.2.4 Write Property Multiple: DS-WPM-A; DS-WPM-B
 - **2.3.3.7.3** Device and Network Management:
 - 2.3.3.7.3.1 Dynamic Device Binding: DM-DDB-A; DM-DDB-B
 - 2.3.3.7.3.2 Dynamic Object Binding: DM-DOB-A; DM-DOB-B
 - 2.3.3.7.3.3 Time Synchronization: DM-TS-A; DM-TS-B
 - 2.3.3.7.3.4 UTC Time Synchronization: DM-UTC-A; DM-UTC-B
- **2.3.3.8** The following is the list of the mandatory Bacnet Object Types for the B-AAC and B-ASC:

- **2.3.3.8.1** Analog Input
- **2.3.3.8.2** Analog Output
- **2.3.3.8.3** Analog Value
- **2.3.3.8.4** Binary Input
- **2.3.3.8.5** Binary Output
- **2.3.3.8.6** Binary Value
- **2.3.3.8.7** Multistate Value
- 2.3.3.8.8 Notification Class
- **2.3.3.9** Three (3) mandatory BACNET Alarm Notification classes must be created in the B-AAC and B-ASC with the following definitions:
 - **2.3.3.9.1** Notification Class URGENT Bacnet Priority 80
 - **2.3.3.9.2** Notification Class HIGH Bacnet Priority 160
 - **2.3.3.9.3** Notification Class LOW Bacnet Priority 240

All the Notification Classes shall allow to modify the Priorities through EMRS.

The Notification Class object name must comply with the following naming convention:

xxx_DDCyy_NCz_URGENT – for Urgent priority

xxx_DDCyy_NCz_HIGH – for High priority

xxx_DDCyy_NCz_LOW – for Low priority

where:

xxx – building number

yy – controller index

z – Notification Class index

All process values shall be assigned to the Notification Class LOW priority by default.

UofT Project Team will reassign the priorities for the process values based on the internal process.

- **2.3.3.10** B-ASC and B-AAC functionality and compliance with BIBB and Object Types shall be presented to the U of T Project Team before shop drawing submission. Functionality must be approved by the U of T Project Team.
- **2.3.3.11** All AACs and ASCs shall be BTL listed.
- **2.3.3.12** AAC(s) and ASC(s) shall communicate to the BACNET Building Controller (B-BC) on the RS485 MSTP field bus.

IMPORTANT NOTE: Maximum of 27 MSTP device can be connected to the single B-BC controller.

2.3.3.13 AAC and ASC Input-Output Processing

2.3.3.13.1 Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or 24 VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output

shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure. Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.

- **2.3.3.13.2** Analog Inputs (AI): AI shall be O-5 Vdc, 0-10Vdc, and 4-20 mA Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the ASC/AAC's board (multiplexing to a separate manufacturers board is unacceptable). A/D converters shall have a minimum resolution of 12 bits.
- **2.3.3.13.3** <u>Digital Inputs (DI):</u> Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the ASC/AAC and shall be isolated from the main board.
- **2.3.3.13.4** <u>Universal Inputs (UI-AI or DI)</u>: To serve as either AI or DI as specified.
- **2.3.3.13.5** Electronic Analog Outputs (AO): Voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. D/A converters shall have a minimum resolution of 12 bits.
- **2.3.3.13.6** Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer or 0-10vdc to pneumatic transducer are acceptable. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
- **2.3.3.14** Mandatory ASC/AAC As-Built submittals must be provided for all the MSTP controllers, in order to determine the point mapping and the point description that is associated with every ASC/AAC application. In cases where the vendor is using any variations of the ASC/AAC application (sometimes referred to as TEC Application Number), the detailed specification document must be provided as part of the as-built package.
 - **2.3.3.14.1** Please refer to the Section 3.23 (Application Specific Controllers Submittal Package) for the details of the reports requirements

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2.3.4 Service Tool

- **2.3.4.1** Service Tool is supplied by F&S IT when required. The BAS contractor is responsible for software that allows complete configuration of the BAS.
- 2.3.4.2 Control Manufacturers Software
 - **2.3.4.2.1** Provide all licensed software associated with the project to the U of T Project Team.
 - **2.3.4.2.2** The software must include the following:
 - a) All licenses and operating keys.
 - b) Most recent Service/Technicians Tools Software as used by the manufacturers Service Technicians.
 - c) Capable of programming and servicing all the DDC devices.
 - d) Backup and restore controller databases.
 - e) Add, modify and delete any existing or new system points.
 - f) The software must include a help files and a fully open library of the manufacturers installed control devices.
 - g) include the latest controller global library
 - h) if controller databases exist for any given project, the latest version must be provided.
 - **2.3.4.2.3** Warranty and Licenses:
 - a. Include all software updates during the warranty
 - b. Unlimited license without annual fees.
 - **2.3.4.2.4** Provide all necessary interface cables for servicing the project controllers.

The project consultant confirming that all the requirements in the Section 2.3 of this document have been incorporated in the project's Design Specification documentation.					
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 					
Provide the expl	anation, if NO or N/A options ar	re selected:			
2 0	-		etween the sections in the Building		
Building Autor	Energy Systems Design Standard mation and Energy Systems		Design Specification		
Design Standar Ex. 2.3	ď	22.13			
CHECKLIST 9 Date:	Consulting Engineer:		Signature:		

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2.4 INSTRUMENTATION

2.4.1 General Notes

- **2.4.1.1** It is the responsibility of the Project Consultant to ensure that the project design specifications include all requirements below.
- **2.4.1.2** All remote access instrumentation is to be compatible with the BAS and EMRS for data access, control and monitoring. Systems with BACNET protocol compatibility shall be the basis for all BAS instrumentation where applicable.
- **2.4.1.3** All sensor, devices and instrumentation locations shall be shown on the mechanical drawings and approved by the UofT Project Team.
- **2.4.1.4** BAS Contractor shall provide and install all instrumentation required to satisfy the Sequences of Operation.
- **2.4.1.5** The following list of Instrumentation describes minimum specifications. The Contractor is encouraged to suggest alternates that are more current in design for review and approvals by the U of T Project Team.
- **2.4.1.6** The U of T Project Team is permitted to alter these specifications on a project by project basis if required.
- **2.4.1.7** BAS Project Consultant is required to coordinate with the Mechanical and Electrical contractors for supply of BAS components that may over-lap such as metering, valves, line voltage devices. When in doubt, BAS Project Consultant shall contact the U of T Project Team for clarity.

2.4.2 Temperature Sensors

- **2.4.2.1** Platinum or Nickel RTD type sensors, either 100 ohm 3-wire Platinum at 0° C. Class B, or, 1000 ohm Platinum at 0° C. (both with coefficient of resistivity of 0.00385 ohms/ohm/° C.).
- **2.4.2.2** If the RTD is 1,000 ohm Platinum or Nickel, provide a transmitter at the RTD when the I/O subsystem at the controller cannot interface directly to an RTD or if the distance between the RTD and the associated controller exceeds 50m.
- **2.4.2.3** The end-to-end accuracy for all BAS monitored temperature sensors shall be $\pm 0.2^{0}$ C. (See 2.5.13 for temperature sensors used in metering)
- **2.4.2.4** Positive temperature coefficient thermistor type temperature sensors are acceptable for space temperature sensing associated with terminal units.

2.4.3 Outside Air Temperature Sensor

- **2.4.3.1** Ventilated white PVC sun shield.
- **2.4.3.2** Wall mounted weather proof enclosure with conduit fitting, accessible for maintenance.
- **2.4.3.3** If not installed at a northern exposure, determine location with U of T Project Team.
- **2.4.3.4** Operating temperature range of -50 $^{\circ}$ C to +50 $^{\circ}$ C.
- **2.4.3.5** Not installed near any exhaust vents or other sources of heat or cold.

2.4.4 Duct Temperature Sensors

2.4.4.1 Single point type sensor probe. Sensor probe length shall be no less than 1/3 of duct width or diameter.

- **2.4.4.2** Complete with duct mounting facilities and conduit fittings.
- **2.4.4.3** Operating temperature range of 0 ° C to 65 ° C.

2.4.5 Duct Averaging Temperature sensors

- **2.4.5.1** Duct averaging probe materials may be stainless steel, copper or aluminum. The probe length must be 3.7m minimum or 3.25m per sq.m. of duct cross-sectional area, whichever is greater.
- **2.4.5.2** Duct mounted moisture/waterproof housing with conduit fitting.
- **2.4.5.3** Suitable supports at all bends and at intermediate points to prevent movement in the air stream using capillary clips and protection where capillary goes through fan casing.
- **2.4.5.4** Operating temperature range of -5 $^{\circ}$ C to 50 $^{\circ}$ C.

2.4.6 Space Thermostats

- **2.4.6.1** All thermostats must be capable of temperature monitoring, temperature indication, set point adjustment, set point limiting, occupied/unoccupied mode selection, over ride and reporting to the BAS/EMRS.
- **2.4.6.2** The actual space thermostat configuration shall be confirmed in written by UofT Project Team otherwise the options listed in the section 2.4.6.1 shall be provided.
- **2.4.6.3** The accuracy of the temperature sensor must be $\pm -0.2^{\circ}$ C.
- **2.4.6.4** All non-common area space thermostats shall have exposed temperature set point adjustment. Set points are limited to between 18° C and 23°C and shall be capable of remote reset by the BAS/EMRS.
- **2.4.6.5** Space thermostats must have a programmable timed override request push button with LED status.
- **2.4.6.6** All space thermostats in public/common areas, such as, corridors, lobbies, cafeterias, gyms, auditoriums, classrooms, etc. will have no setpoint adjustment with blank covers or lockable protective enclosures. Blank covers or enclosures to be ventilated.
- **2.4.6.7** Insulated mounting bases must be installed when thermostat are located on exterior walls.

2.4.7 Electric Line Thermostat

- **2.4.7.1** Provide heating/cooling type thermostat with dead-band where sequencing of heating and cooling/ventilation is required.
- **2.4.7.2** Line-voltage thermostats shall be UL-listed, SPDT, SPST, or DPST with contact rating suitable for application, maximum 1.5 ⁰ C differential.
- **2.4.7.3** Provide heavy duty type. Include back plate and bracket for mounting on standard size outlet box where required.
- **2.4.7.4** Standalone line thermostats are not considered a component of the BAS/EMRS.
- **2.4.7.5** Provide isolation switch or list thermostats power source and label it at thermostat

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2.4.8 Electric Low Voltage Thermostat

- 2.4.8.1 Provide complete with heat anticipator, and back plate and bracket for mounting on standard size outlet box where required. Include sub-base with fan On-Off-Auto switch with each thermostat where summer ventilation is required. Include modulating heating or cooling stage where used in conjunction with control valves; step controllers; SCR's; or similar equipment requiring modulation, and switches where On-Off control is required.
- **2.4.8.2** Standalone thermostats are not considered a component of the BAS/EMRS.

2.4.9 Standalone Space Thermostats

- **2.4.9.1** Low-voltage thermostats shall be single or multi-stage heating and/or type as required by application.
- **2.4.9.2** Combination heating/cooling thermostats shall have independent adjustments for heating and cooling set points and shall not allow set point crossover.
- **2.4.9.3** Provide individual heat or cooling anticipator for each control stage. Anticipator shall be matched to connected load, or shall be adjustable.
- **2.4.9.4** Suitable switch sub-bases shall be provided when required by application, with switch functions clearly identified by permanent labels. Field-applied "stick-on" labels are not acceptable.
- **2.4.9.5** Microprocessor-based programmable type thermostats, when used, shall not lose time or program upon power failures of 12 hours or less and must have password protection capability.
- **2.4.9.6** All space thermostats in non-common areas shall have exposed temperature setpoint adjustment. The temperature setpoint is limited to 18° C and 23°C.
- **2.4.9.7** All space thermostats in public areas, such as, corridors, lobbies, cafeterias, gyms, auditoriums, classrooms or as specified will have no setpoint adjustment. Blank covers and enclosures shall be ventilated.
- **2.4.9.8** Insulated mounting bases shall be installed when thermostats are located on exterior walls and at locations approved by UofT Project Team.

2.4.10 Space Temperature Sensors

- **2.4.10.1** The accuracy of the temperature sensor must be $\pm -0.2^{\circ}$ C.
- **2.4.10.2** Space temperature sensors do not have set point adjustment.
- **2.4.10.3** Blank covers or enclosures shall be ventilated.

2.4.11 High Precision Temperature Sensors: Used in energy metering applications

- **2.4.11.1** Tip-Sensitive RTD sensors complete with 316 drilled stainless steel thermo-wells.
- **2.4.11.2** 100 ohm Platinum Class A (100 ohm +/- 0.06 ohm @ 0 ⁰ C.) stainless steel sheathed element.
- **2.4.11.3** Three-wire RTD's compensate for resistance.
- **2.4.11.4** The sensors must be a matched pair.

2.4.12 Thermowells

- **2.4.12.1** Stainless steel (316 SST ¾ inch) probe. Probe length shall be at minimum 30% of the pipe width.
- **2.4.12.2** Moisture/waterproof housing with conduit fitting.
- **2.4.12.3** Provide complete with drilled Stainless Steel thermowells.
- **2.4.12.4** Provide complete with thermal transfer compound inside thermal well.

2.4.13 Low Temperature Detection Device

- **2.4.13.1** Duct mounted Freeze protection is a dedicated equipment protection system and is not required to be incorporated into the BAS/EMRS unless specifically requested by UofT Project Team.
- **2.4.13.2** Minimum 6.1 m vapour tension element, which shall serpentine on the inlet face on all coils. Provide additional sensors, wired in series, to ensure 3.25 m per sq.m. of coil surface area.
- **2.4.13.3** Provide freeze stat for each 3.25m² of duct area where necessary, wired in series with safety circuit.
- **2.4.13.4** Hardwire interlock device to shut down fans and position mixing dampers to the full recirculation position. Refer to sequences of operation.
- **2.4.13.5** Provide device hardwire interlocked such that AHU fan will shut down when HOA switch is in Hand or Auto position.
- **2.4.13.6** Manual reset
- **2.4.13.7** Set-point shall be adjustable in the range of, minimum, 0^{0} C to 7^{0} C. Provide a scale with temperature setting clearly displayed.
- **2.4.13.8** SPDT switch contacts. Switch contacts shall be rated for duty.
- **2.4.13.9** Provide suitable supports.
- **2.4.13.10** Provide complete with auxiliary contacts for monitoring by the BAS.
- **2.4.13.11** Must be mounted horizontally across the coil using capillary clips.
- **2.4.13.12** Where capillary enters through fan cabinet to have protective sleeve around capillary.

2.4.14 Relative Humidity Sensors

- **2.4.14.1** Overall accuracy of +/- 3 % reading from 0 to 95 % RH unless the UofT Project Team specifies higher accuracy for the application.
- **2.4.14.2** Operating temperature range of -20° C to 80° C.
- **2.4.14.3** Long term stability with less than 1 % drift per year.
- **2.4.14.4** Sensitivity of 0.5 % RH.
- **2.4.14.5** Complete with built in transmitter for 2- 10 VDC 0r 4-20 mA output proportional to RH. Humidity sensor shall be replaceable.

2.4.15 Outdoor Air Relative Humidity Sensors

- **2.4.15.1** Non-corroding outdoor shield to minimize wind effects and solar heating.
- **2.4.15.2** Wall mount weather proof enclosure with conduit fitting. Must be mounted in location that is accessible for repair or replacement.

2.4.16 Duct mount Relative Humidity sensors

- **2.4.16.1** Duct mount moisture resistant enclosure with conduit fitting.
- **2.4.16.2** 20 cm probe length.

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- **2.4.16.3** Operating temperature range of 0° C. to 50° C.
- **2.4.16.4** Sensor shall be suitable for operation in moving air streams.

2.4.17 Space Relative Humidity sensors

- **2.4.17.1** Suitably finished wall mounted enclosure with discrete manufacturer logos markings only. Enclosure shall not have temperature or RH indication devices.
- **2.4.17.2** Provide protective ventilated enclosures for all sensors mounted in mechanical and electrical rooms, janitor closets, any public spaces.

2.4.18 Combination Relative Humidity and Temperature Sensors

2.4.18.1 Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BAS contractor may provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications detailed above.

2.4.19 Combination Dewpoint and Dry Bulb Temperature Transmitter

- **2.4.19.1** Complete with mounting accessories and enclosures for interior or exterior wall or duct mounting.
- **2.4.19.2** Stainless steel probe with NEMA 4 transmitter housing. Outside air sensor shall have a solar shield.
- **2.4.19.3** Two wire, 4-20 mA output proportional to minimum dewpoint temperature range of -40 $^{\circ}$ C to +63 $^{\circ}$ C.
- **2.4.19.4** Two wire, 4-20 mA output proportional to minimum dry bulb temperature range of -23° C to $+79^{\circ}$ C.
- **2.4.19.5** Probe shall be a minimum of 200mm for duct application.
- **2.4.19.6** BAS/EMRS shall report the monitored dry bulb temperature with an accuracy of $\pm 0.2^{0}$ C.
- **2.4.19.7** BAS shall report the monitored dewpoint temperature with an accuracy of $\pm 1.0^{\circ}$ C at 50% RH and dry bulb temperature of -25° C to $+65^{\circ}$ C.

2.4.20 Latching Type Control Relays

- **2.4.20.1** Pickup rating, time and hold rating as required for individual applications
- **2.4.20.2** Rated for a minimum of ten (10) million mechanical operations and a minimum of 500,000 electrical operations.
- **2.4.20.3** Provide complete isolation between the control circuit and the BAS digital output.
- **2.4.20.4** Located in the BC, ASC, AAC or other local enclosures.
- **2.4.20.5** Malfunction of a BAS component shall cause the controlled output to fail to the positions identified in the failure procedure.
- **2.4.20.6** 10 amp contact rating.
- **2.4.20.7** Pin type terminals complete with mounting bases

2.4.21 Momentary Type Control Relay

2.4.21.1 Coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application.

- **2.4.21.2** Provide complete isolation between the control circuit and the BAS digital output.
- **2.4.21.3** Located in the BC, ASC, AAC or other local enclosures.
- **2.4.21.4** 10 amp contact rating.
- **2.4.21.5** LED status indication

2.4.22 Duct Static Pressure Transmitter

- **2.4.22.1** Input pressure range to suit each individual application.
- **2.4.22.2** 4-20 mA output signal proportional to pressure input range.
- **2.4.22.3** \pm 2.5% accuracy.
- **2.4.22.4** Operating temperature range of -7° C to 50° C.
- **2.4.22.5** Easily accessible, integral non-interacting zero and span adjustment.
- **2.4.22.6** Minimum over pressure input protection of five times rated input.
- **2.4.22.7** Basis of design, Setra or Greystone

2.4.23 Space Static Pressure Transmitter

- **2.4.23.1** Input range to suit application. Typically input range of -0.25 to +0.25 inches w.c.
- **2.4.23.2** 4-20 mA output proportional to pressure input range. ± 2.5% accuracy of range.
- **2.4.23.3** Temperature range of 0° C to 38° C.
- **2.4.23.4** Easily accessible, integral non-interacting zero and span adjustment.
- **2.4.23.5** Over pressure input protection of five times rated input.
- **2.4.23.6** Exterior static pressure references shall be monitored via a static pressure sensor dampening pot. Coordinate exact mounting locations of exterior static pressure reference points with UofT Project Team.
- **2.4.23.7** Basis of design, Setra or Greystone.

2.4.24 Air Flow Rate Sensor

- **2.4.24.1** Duct mounted Multipoint flow cross or grid measuring device. Complete with transducer and range appropriate for application.
- **2.4.24.2** Bulkhead fittings to allow sensor tubing to be connected or removed without removing ductwork.
- **2.4.24.3** Internal materials of the transducer suitable for continuous contact with air.
- **2.4.24.4** Sensing grid shall be constructed of stainless steel.
- **2.4.24.5** Integral signal integrator to minimize primary signal noise from the output signal.
- **2.4.24.6** Output signal of 4-20 mA proportional to input pressure.
- **2.4.24.7** Temperature range of -18° C to 60° C. \pm 2.5% accuracy of measured value.
- **2.4.24.8** Transducer to be provided complete with easily accessible, integral non-interacting zero and span adjustment.

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2.4.25 Air Flow Rate Sensor - Fan Inlet

- **2.4.25.1** Multipoint flow cross or grid measuring device mounted at the inlet of the fan.
- **2.4.25.2** Complete with transducer. Input range appropriate to application.
- **2.4.25.3** Bulkhead fittings to allow sensor tubing to be connected or removed without removing the device from the fan.
- **2.4.25.4** Internal materials of the transducer suitable for continuous contact with air.
- **2.4.25.5** Sensing grid shall be constructed of stainless steel.
- **2.4.25.6** Integral signal integrator to minimize primary signal noise from the output signal.
- **2.4.25.7** Output signal of 4-20 mA proportional to input pressure.
- **2.4.25.8** Temperature range of -18° C to 60° C.
- **2.4.25.9** Combined sensor and transducer accuracy of $\pm 2.5\%$ of measured value.
- **2.4.25.10** Transducer to be provided complete with easily accessible, integral non-interacting zero and span adjustment.

2.4.26 Current Sensing Transformer and Relay Combination

- **2.4.26.1** Rated for the applicable load.
- **2.4.26.2** SPDT Status Indication relay contacts. Status indication relay shall have an accessible trip adjustment over its complete operating range. Provide LED indication of relay status.
- **2.4.26.3** Long term drift shall not exceed 2.5% of full range per 6 months.
- **2.4.26.4** Current transformer and relay shall have over current and over voltage protection.
- **2.4.26.5** Transformer and relay may be combined into a single unit or can be separate units.
- **2.4.26.6** Transformer core shall be sized for the application.
- **2.4.26.7** Accuracy- \pm 2% of reading from 10% to 100% of full scale range, \pm 2% full scale from 0 to 10% of full scale range.
- **2.4.26.8** Temperature range of -15 0 C to 60 0 C.
- **2.4.26.9** For new installations, solid core shall be used.
- **2.4.26.10** Split core, when used, shall be complete with LED indication and have a zero and span adjustments.
- **2.4.26.11** Relay portion shall not be installed in within the MCC tubs. Relay portion shall be installed in local field panel enclosure, in the BC, ASC, AAC enclosure, or in the wiring channel between MCC tubs. Provide device securely mounted with screw type wire terminations.
- **2.4.26.12** Device shall be mounted for easy access.

2.4.27 Water Differential Pressure Sensor: (not used in flow metering)

- **2.4.27.1** Cast aluminum NEMA 1 enclosure.
- **2.4.27.2** Complete with transducer with output of 4-20 mA proportional to the pressure sensed.
- **2.4.27.3** Over pressure protection of five times the rated input.
- **2.4.27.4** Easily accessible, integral non-interacting zero and span adjustment.
- **2.4.27.5** Operating range to suit application.

- **2.4.27.6** Accuracy of \pm 2% of full scale reading.
- **2.4.27.7** Valve taps shall be installed by the Mechanical subcontractor.
- **2.4.27.8** Basis of design, Setra, or Greystone.

2.4.28 Differential Pressure Switch - Duct Static Pressure Limit

- **2.4.28.1** UL, CSA listed and approved.
- **2.4.28.2** SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.
- **2.4.28.3** Adjustable set-point with a setpoint range to suit the application.
- **2.4.28.4** 1/4 inch compression fittings suitable for copper sensing tubing.
- **2.4.28.5** Temperature range of -18 ⁰ C to 71 ⁰ C.
- **2.4.28.6** Manual reset.
- **2.4.28.7** Provide sensing inputs complete with signal dampening facilities to prevent nuisance tripping where required.

2.4.29 Differential Pressure Switch - Filter Status Indication

- **2.4.29.1** UL, CSA listed and approved.
- **2.4.29.2** SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.
- **2.4.29.3** Adjustable set-point with a setpoint range to suit the application.
- **2.4.29.4** 1/4 inch compression fittings suitable for copper sensing tubing.
- **2.4.29.5** Operating range to suit application.
- **2.4.29.6** Automatic reset
- **2.4.29.7** Basis of design as manufactured by Dwyer, or approved equal.

2.4.30 Differential Pressure Switch - Water Service (not used in flow metering)

- **2.4.30.1** UL, CSA listed and approved.
- **2.4.30.2** SPDT or two SPST switches rated for 10 amps minimum at 120 Vac.
- **2.4.30.3** Adjustable set-point with a setpoint range to suit the application.
- **2.4.30.4** 1/4 inch compression fittings suitable for copper sensing tubing.
- **2.4.30.5** Operating temperature and pressure range to suit application.
- **2.4.30.6** Durable NEMA-4 rated enclosure.
- **2.4.30.7** Provide sensing inputs complete with signal dampening facilities to prevent nuisance tripping where required.
- **2.4.30.8** Suitable for continuous contact with the sensed fluid and rated for operating temperature.
- **2.4.30.9** Repeatability of +/- 1 % of span.
- **2.4.30.10** Over pressure input protection to a minimum of five (5) times rated input.
- **2.4.30.11** Basis of design, Dwyer or Penn.

2.4.31 Water Pressure Sensor

- **2.4.31.1** Input range of 0 to 200 psi or as per UofT Project Team.
- **2.4.31.2** Complete with transducer with 4-20 mA output signal proportional to water pressure.
- **2.4.31.3** 0.5% accuracy over entire sensing range.
- **2.4.31.4** Temperature range of 0 ⁰ C to 38 ⁰ C.
- **2.4.31.5** Transducer with easily accessible, integral non-interacting zero and span adjustment.
- **2.4.31.6** Over pressure input protection of two times rated input.

- **2.4.31.7** NEMA-4 rated fittings.
- **2.4.31.8** Stainless steel wetted parts.
- **2.4.31.9** Burst pressure of 5 times rated input
- **2.4.31.10** Long-term stability of .25 percent of full scale.
- **2.4.31.11** Shall be ANSI 300 rated or as per UofT Project Team.
- **2.4.31.12** Stainless Steel wetted parts suitable for continuous contact with the sensed medium.
- 2.4.31.13 Basis of design, Dwyer

2.4.32 Air Quality Sensor

- **2.4.32.1** Measurement of volatile organic compounds (VOC) containing, at minimum, the following gases: **Methane, Ethylene, Hydrogen, Carbon Monoxide, Carbon Dioxide, Ammonia.**
- **2.4.32.2** Ventilated cover, Circuit board covered by polycarbonate housing.
- **2.4.32.3** 135 mA max current, 4 K OHMS min. load resistance, 24 VAC + 10%, 50% or 24DC. (Min. 12V, Max 24V) power supply.
- **2.4.32.4** Rate of rise circuit to filter out short term disturbances and provide a stable output.
- **2.4.32.5** Temperature range of 0 °C to 60 °C.
- **2.4.32.6** Mounting and enclosure suitable for duct air or space air monitoring as specified.
- **2.4.32.7** Monitoring system shall be manufactured by Arjay Engineering Ltd.

2.4.33 Carbon Dioxide Sensor

- **2.4.33.1** Negligible temperature and humidity effect on accuracy.
- **2.4.33.2** Complete with transducer with selectable 4-20 mA or 0-10VDC output signal proportional to carbon dioxide concentration.
- **2.4.33.3** 0 2000 ppm CO₂ sensing range.
- **2.4.33.4** Manufacturer 5 year or longer calibration interval guarantee.
- **2.4.33.5** Accuracy- \pm 3% of reading or \pm 50 ppm, whichever is the more stringent requirement over 15 0 C to 32 0 C temperature range. Accuracy of +/- 5 % or 100ppm of reading whichever is the more stringent requirement over 0 0 C to 50 0 C temperature range.
- **2.4.33.6** Annual Drift not to exceed +/- 10 ppm.
- **2.4.33.7** Operating temperature of 0 ⁰ C to 50 ⁰ C.
- **2.4.33.8** Complete with auxiliary relay contacts for alarm indication.
- **2.4.33.9** For space monitoring applications provide with a blank, white enclosure with no manufacturer Logo or LED indication.
- **2.4.33.10** For duct sensing applications provide sensor complete with aspiration box and air stream sensor.
- **2.4.33.11** Non-dispersive Infrared technology based sensor.
- **2.4.33.12** Basis of design, Vaisala.

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2.4.34 Occupancy Sensor

- **2.4.34.1** The Occupancy Sensor system shall sense the presence of human activity within the desired space and fully control the on/off function of the loads automatically. Sensors shall turn on the load within 0.6m of entrance.
- **2.4.34.2** Sensing technologies shall be completely passive in nature, in that the occupancy sensor system shall not emit or interfere with any other electronic device, or human characteristic. Acceptable known technologies are Passive Infrared (PIR) or Thermal Imaging.
- **2.4.34.3** Upon detection of human activity by the detector, a Time Delay shall be initiated to maintain the "ON" state as specified and be field adjustable from 30 seconds to 20 minutes.
- **2.4.34.4** All sensors shall have non-adjustable factory calibrated sensitivity for maximum performance. Time Delay and field adjustments shall be provided as needed.
- **2.4.34.5** The installing contractor shall be responsible for a complete and functional system. Proper coverage of the area for all types of human activity, and any necessary relays or miscellaneous devices is the responsibility of the contractor.
- **2.4.34.6** Occupancy sensors may be connected to the BAS or stand alone and direct to load (i.e., lighting). Application and control functionality to be defined in the sequences of operation.

2.4.35 Occupancy Demand Control Sensor

- **2.4.35.1** A thermal array based sensor that counts occupants entering and leaving the monitored space shall be the basis of design for demand control of HVAC equipment where possible.
- **2.4.35.2** Project Consultant is responsible for coordinating the locations of the sensors and any related equipment such as repeaters, nodes, masters/slaves and power as required to furnish an operating system.
- **2.4.35.3** All data shall be communicated to the EMRS. Project Consultant will coordinate with U of T Project Team for required integration with EMRS.
- **2.4.35.4** Counter has self-contained imaging optics, IR sensor, signal processing and interfacing electronics in a ABS package capable of ceiling mounting with twist off front piece for service.
- **2.4.35.5** Unit uses the infra-red signature of people only no other identifying features are to be captured.
- **2.4.35.6** Up to 8 units can be connected in series to allow for large zone entrance areas.
- **2.4.35.7** People are counted as "net" remaining in the controlled zone with multiple and user programmable count increment modes (crossing the line, leaving the field of view, U-turns, direction).
- **2.4.35.8** Data output and configuration can be via IP connection or direct serial connection to the master unit.
- **2.4.35.9** U of T shall be able to completely configure the system and access all the data without requiring third party service teams. All firmware upgrades shall be possible remotely via IP.
- **2.4.35.10** Can be powered over CAT5.

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- **2.4.35.11** Sensors can operate indoors between 0° C and 40° C.
- **2.4.35.12** Basis of design is using InfraRed Integrated Systems, IRC 3000 series.

2.4.36 Refrigeration Alarm/Monitoring System

- **2.4.36.1** Refrigeration Alarm/Monitoring system must be installed according to B52 standards and follow all TSSA requirements.
- **2.4.36.2** Must have a local LCD display complete with membrane keypad for user interface.
- **2.4.36.3** Alarm/Monitoring system must have Password protection.
- **2.4.36.4** The ventilation starter system should have HAND and AUTO switch only. (no OFF position)
- **2.4.36.5** Alarm/Monitoring system must have local audible, visual alarm and remote alarm capabilities.
- **2.4.36.6** Communication capabilities to the EMRS via Modbus RTU, Modbus TCP/IP, BACNET/IP and relay contacts for alarming.
- **2.4.36.7** Refrigeration Alarm/Monitoring system shall be manufactured by either Honeywell Vulcain or Arjay Engineering Ltd Refrigerant Gas Monitor.

2.4.37 Chiller Vent Pipe Refrigerant Leak Monitoring

- **2.4.37.1** Refrigerant monitoring sensor must be installed in vent pipe on each chiller.
- **2.4.37.2** The sensor will be added to the Chiller Mechanical Room leak monitoring system panel.
- **2.4.37.3** Refrigerant Alarm/Monitoring system shall be manufactured by either Honeywell Vulcain or Arjay Engineering Ltd.

2.4.38 Parking Garage Carbon Monoxide (CO) Alarm/Monitoring System

- **2.4.38.1** Carbon Monoxide (CO) Alarm/Monitoring system must comply with the Ontario Building Code 2012- Garage Ventilation.
- **2.4.38.2** Shall have a local LCD display complete with membrane keypad for user interface unless otherwise specified by U of T Project Team.
- **2.4.38.3** Alarm/Monitoring system shall have Password protection.
- **2.4.38.4** Alarm/Monitoring system shall have local audible, visual alarm and remote alarm capabilities.
- **2.4.38.5** Communication capabilities to the EMRS via Modbus RTU, Modbus TCP/IP, BACNET/IP and relay contacts for Alarming.
- **2.4.38.6** Carbon Monoxide (CO) Alarm/Monitoring system shall comply with the Ontario Building Code 2012 Garage Ventilation.
- **2.4.38.7** Shall have a local LCD display complete with membrane keypad user interface.
- **2.4.38.8** Alarm/Monitoring system shall have Password protection.
- **2.4.38.9** Alarm/Monitoring system shall have local audible, visual alarm and remote alarm capabilities.
- **2.4.38.10** Communication capabilities to the EMRS via Modbus RTU, Modbus TCP/IP, BACNET/IP and relay contacts for Alarming.

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2.4.38.11 Carbon Monoxide (CO) Alarm/Monitoring system shall be manufactured Arjay Engineering Ltd model # 4300-PG.

2.4.39 Damper Position Switch

- **2.4.39.1** Mechanically actuated electrical switch.
- **2.4.39.2** Provide damper end switch which indicates actual damper blade position.
- **2.4.39.3** Damper position switches which are actuated by damper crankshaft or actuator position will not be accepted.
- **2.4.39.4** Contacts shall be rated for the electrical load to be switched.
- **2.4.39.5** Provide Auxiliary contacts as required.

2.4.40 Electronic to Pneumatic Transducers

- **2.4.40.1** Provide current-to-pneumatic (I/P) transducers for BAS DDC control of pneumatically actuated devices.
- **2.4.40.2** Output range shall be as required for the control device.
- **2.4.40.3** Provide device mounted within the associated BC/ASC/AAC controller panel or remote field panel enclosure mounted adjacent to the associated BC/ASC/AAC.
- **2.4.40.4** Operable temperature range of, at minimum, -10^o C. to 50^o C. with 5% to 90% RH (non-condensing).
- **2.4.40.5** Internal materials suitable for continuous contact with commercial standard controls air supply.
- **2.4.40.6** Combined non-linearity, hysteresis and repeatability effects not to exceed +/- 2% of span over the entire range.
- **2.4.40.7** Integral and accessible zero and span adjustments.
- **2.4.40.8** Complete with pressure gauge on the pneumatic control output.

2.4.41 Fluid Flow Measurement – BTU Energy

2.4.41.1 Flow metering installations shall be provided for the measurement of Steam, High Temperature Hot Water (supply and return), Hot Water Heating (supply and return), Chilled Water (supply and return), condenser water (supply and return), Domestic City Water and Condensate.

2.4.42 Metering Devices: Steam, Heating/Cooling water and Condensate.

- **2.4.42.1** Flow metering used for measuring energy consumption.
- **2.4.42.2** Flow metering installations shall in compliance with governing body regulations such as ISO, API, AGA and ANSI 2530/ASME Fluid Meters standards.

2.4.43 Mass Flow Density Compensation and BTU Devices

Requirements for Temperature Compensation:

- **2.4.43.1** High Precision Temperature Sensors used in metering (eg. BTU) applications must be in compliance with the following requirements:
- **2.4.43.2** Tip-Sensitive RTD sensors complete with 316 drilled stainless steel thermo-wells.

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- **2.4.43.3** The RTD is 100 ohm Platinum Class A (100 ohm +/- 0.06 ohm @ 0⁰ C.) stainless steel sheathed element.
- **2.4.43.4** Four-wire RTD's compensate for resistance resulting from length.
- **2.4.43.5** The sensors must be a matched pair.
- **2.4.43.6** Provide thermowells for temperature sensors in compliance with the following requirements:
 - a) Stainless steel probe length shall be at minimum 30% of the pipe width.
 - **b)** Moisture/waterproof housing with conduit fitting.
 - c) Provide complete with thermal transfer compound inside thermal well.

Requirements for Pressure compensation:

- **2.4.43.7** Gauge Pressure Transmitter used in metering (eg. BTU) applications shall be in compliance with the following requirements:
 - a) 0.035 percent span accuracy, 150:1 range turndown, 15-yr stability
 - **b)** Output 4-20 mA and HART protocol.
 - c) Provide a two valve manifold (316SST) for instrument isolation and a drain/vent valve rain/vent valve allows venting, draining, or calibration.
- **2.4.43.8** Provide devices as manufactured by Rosemount MVP Series.

2.4.44 Steam Flow & BTU Measurement

- **2.4.44.1** For Steam Flow measurement provide Inline Linear Variable Area (ILVA) meter device complete with a Smart Differential Pressure Transmitter. The Smart Transmitter must have the following:
 - a) Shall have Density Compensation via Pressure and /or Temperature.
 - **b)** Password protected security access.
 - c) A lithium battery for backup.
 - **d**) USB communication adaptors complete with blanking plug & an universal serial bus A/B cable for a PC.
 - e) An external 24VDC power supply
 - f) Capable of 4 20 ma analog, pulse and RS 485 outputs.
 - g) Accuracy $\pm 0.05\%$ for Spans >10% of the URL.
 - **h)** Accuracy ± 0.005 (URL/SPAN) for Spans <10% of the Sensor.
- **2.4.44.2** Must have a local LCD display & flow computer which can be configured for various displays e.g. Flow/Totalizing/BTU etc. unless otherwise approved by the U of T Project Team.
- **2.4.44.3** Communication shall be to the EMRS via approved communication protocols.
- **2.4.44.4** The Gilflo flow meter shall be a spring loaded variable area orifice with high turndown capability (100:1). Unit to be sized by Mechanical Consultant.

2.4.45 BTU Metering used for U of T Client Billing Purposes

- **2.4.45.1** Meters used in Billing shall in compliance with governing body regulations such as ISO, API, AGA and ANSI 2530/ASME Fluid.
- **2.4.45.2** All BTU Metering shall be remotely monitored by EMRS via Modbus RTU, Modbus TCP/IP, BACNET/IP.

- **2.4.45.3** Shall have Density Compensation via Pressure and /or Temperature.
- **2.4.45.4** High Precision Temperature Sensors as specified in **Section 2.4.13.**
- **2.4.45.5** Must have Local digital display or external Flow Computer Unit.
- **2.4.45.6** The Local display or Flow Computer unit shall be programmable for various flow meter types including linear, square root, multi-point linearization or BTU data interpretation.
- **2.4.45.7** 4-20ma flow input from Flow/Pressure transmitters.
- **2.4.45.8** This Display or Flow computer unit shall operate in an environment of 0^0 C to 50^0 C shall include a keypad for data input and retrieval, and an LCD display.
- **2.4.45.9** Shall include an EEPROM/nonvolatile RAM.
- 2.4.45.10 Power supply shall be 24VDC or 24VAC.
- **2.4.45.11** The flow and BTU data accumulated shall be stored in a battery backed data logger in continuous and periodic modes. Unit shall have a real time clock and shall date stamp logged data. Unit shall have an RS-232 port and shall be capable of setup from the keypad or laptop computer.
- **2.4.45.12** Provide all configuration software and licenses and all required interface cables by the UofT Project Team.
- **2.4.45.13** The BTU Display/Flow computer supplier shall set up, commission and verify BTU measurement and shall train UofT Project Team in all aspects of BTU computer setup and operation.
- **2.4.45.14** BTU meter installation shall be complete including sensor wiring, power wiring, coordination of flow meter installation in a pipeline, setup for operation, labeling, commissioning with commissioning reports.

2.4.46 Water Flow & BTU Measurement (Heating & Chilled)

- **2.4.46.1** Project Consultant shall verify and confirm all meter locations with the U of T Project Team.
- **2.4.46.2** The minimum turndown capability of 40:1.
- **2.4.46.3** Communication shall be to the EMRS via Modbus RTU, Modbus TCP/IP, BACNET MSTP, BACNET/IP.
- **2.4.46.4** Capable of 4 20 ma analog, pulse and RS 485 outputs.
- **2.4.46.5** Must have a local LCD display & flow computer which can be configured for various energy and configuration displays.
- **2.4.46.6** Accuracy; \pm 0.5% 1.0% of flow for velocities greater than 0.3 m/s \pm 0.0015 0.003 m/s for velocities less than 0.3 m/s
- **2.4.46.7** Flow/BTU meters to be sized by mechanical consultant.
- **2.4.46.8** Final commissioned report to be included in OEM manual.
- **2.4.46.9** Basis of design is Siemens Ultrasonic Flow meter Flexim Fluxus or UofT Project Team approved equal.

2.4.47 Condensate Metering

2.4.47.1 A condensate flow meter shall be installed on the line leaving the Condensate tank returning back to the Central Steam Plant. The flow meter must have a working pressure of 230 psi (16 bar) and 130 ⁰ C operating temperature. Equipment with a register reading smallest quantity

- of 1 m³ and a capacity register/pulse counter of 100 m³. Complete with remote reading capability.
- **2.4.47.2** Communication shall be to the EMRS via Modbus RTU, Modbus TCP/IP, BACNET/IP.
- **2.4.47.3** Provide a Kent/AMCO Hot Water Meter Model M190 or an approved equal. (to be sized by mechanical consultant)

2.4.48 Electrical Metering

- **2.4.48.1** It is the intention to sub meter electrical loads that are under the jurisdiction of the F&S Utilities. Electrical metering is to follow the Electrical Standards for application and installation. **See Section Electrical Standards: Metering**.
- **2.4.48.2** Submetering refers to meters that are installed after the main utility meter and within the building.
- **2.4.48.3** All sub meters shall communicate with the EMRS using approved protocols with BACNET IP the basis for design. Minimum data set to be available is; watts, amps, volts, (all phases), kWh, time of day.
- **2.4.48.4** Single or multiple point metering applications shall be determined with the UofT Project Team.
- **2.4.48.5** The UofT Project Team shall approve all metering applications.
- 2.4.48.6 Approved electrical sub meter: Schneider PowerLogic or Triacta

2.4.49 Automatic Control Valves:

- **2.4.49.1** Valve schedules shall be submitted for review and approval by the U of T Project Team and shall clearly show the following for each valve:
 - a) Associated system.
 - b) Manufacturer and model number with the indication of the medium
 - c) Valve size and line size.
 - **d**) Flow-rate, flow coefficient (C_V) and pressure drop at design conditions or valve authority, flow-rate and pressure drop across the valve at design conditions and pressure drop across the associated mechanical equipment, e.g., coil, heat exchanger, etc., at design conditions.
 - e) Valve configuration (e.g. two-way, three-way, butterfly).
 - f) Leakage rate.
 - g) Maximum pressure shut-off capability.
 - h) Actuator manufacturer and model number.
 - i) Valve body pressure and temperature rating.
 - j) Normally open/closed and failure positions
- **2.4.49.2** Valves shall "fail safe" in a normally open or closed position or as dictated by UofT Project Team and shall be easily accessible for servicing. Consultant and BAS Contractor shall verify "fail safe" operation requirements before submitting shop drawings. Default operation is "fail safe".
- **2.4.49.3** All screwed control valves from 13 mm up shall have replaceable stem plug and seat ring.
- **2.4.49.4** Control valve shall be provided with an actuator, sized to allow the control valve to shut off against normal inlet operating pressures

- **2.4.49.5** Pneumatic valve actuators used to sequence multiple valves shall be provided with pilot positioners to ensure proper sequence of each valve and to allow for an adjustable dead band between heating and cooling valves.
- **2.4.49.6** Valves shall have the manufacturer's name and the pressure rating clearly marked on the outside of the body. Where this is not possible manufacturer's name and valve pressure rating shall be engraved on a minimum 50mm diameter stainless steel tag that shall be attached to the valve by a chain in such a manner that it cannot be unintentionally removed.
- **2.4.49.7** Valves 13mm to 50mm shall have screwed ends with union fittings to allow easy removal for servicing. Valves 63mm and larger shall have flanged ends. All valves shall meet the appropriate ANSI requirements.
- **2.4.49.8** The BAS Project Consultant shall certify that the materials of construction are appropriate for the application. In particular, valves used for the control of glycol solutions shall have a trim that is suitable for a glycol solution.

2.4.50 Two-Way Automatic Control Valves

- **2.4.50.1** Shall have equal percentage characteristics.
- **2.4.50.2** Valve shall be capable of tight shut-off when operating at system pressure with the system pump operating at shut-off head. Leakage rate shall not exceed 0.01% of the rated valve capacity.

2.4.51 Three-Way Automatic Control Valves:

- **2.4.51.1** Shall have linear characteristics, sized for maximum 3 psi drop.
- **2.4.51.2** Three way control valves shall be of the mixing or diverting pattern type as indicated in the mechanical documents. The inner valve shall have a linear plug and stainless steel trim. Valves shall have metal-to-metal stainless steel seats to assure tight seating.
- **2.4.51.3** Mixing valves shall be capable of tight shut-off between each inlet port and the outlet port and diverting valves shall be capable of tight shut-off between each outlet port and the inlet port when operating at system pressure.

2.4.52 Water Service Automatic Control Valves:

- **2.4.52.1** Valves for water service shall be provided with Stainless steel stems.
- **2.4.52.2** Valves supplied for water service at 150 psig or less shall be provided with brass plugs and elastomer U- cup or Teflon packing; valves shall be provided with removable brass seat rings.
- **2.4.52.3** Valves supplied for water service over 150 psig shall be provided with stainless steel plugs and Teflon packing; all valve sizes shall be provided with removable stainless steel seat rings.

2.4.53 Steam Service Automatic Control Valves:

- **2.4.53.1** Valves for steam service shall be provided with Stainless steel stems.
- **2.4.53.2** Valves supplied for steam service at 35 psig or less shall be provided with brass plugs and removable brass seat ring and Teflon packing.

- **2.4.53.3** Valves supplied for steam service over 35 psig shall be provided with stainless steel plugs and Teflon packing.
- **2.4.53.4** For steam capacities with modulating steam valves greater than 2000 lbs/hr, two valves shall be supplied and sequenced, one sized for 2/3 and the other for 1/3 capacity.

2.4.54 High Temperature Hot Water Service Automatic Control Valves:

- **2.4.54.1** Flanged bolts to ANSI Class 300 rated flanges (DN 25-300)
- **2.4.54.2** Carbon steel body materials
- **2.4.54.3** Trim, Self-aligning eccentrically rotating plug.
- **2.4.54.4** (DN 80-300) 316L stainless steel with hard faced seating surface
- **2.4.54.5** Seat Ring, solid clamped.
- **2.4.54.6** Upper & Lower Bearings seals must be for slurry/viscous service.
- **2.4.54.7** Operating fluid temperature range, 250° C
- **2.4.54.8** Flow characteristic, standard trim linear.
- **2.4.54.9** Actuator, spring-opposed rolling diaphragm.
- **2.4.54.10** Actuator bench test spring range, 7 24 psi on supply.
- **2.4.54.11** Failsafe normally closed on supply valve and normally open on the bypass valve.
- **2.4.54.12** Shall be Masoneilan valve 35002 Series Camflex® II Complete with SVI-II smart positioner sized by Mechanical Consultant.

2.4.55 Valve Actuators – Electric/Electronic

- **2.4.55.1** The BAS Project Consultant shall design electric/electronic actuators for all valves except as noted in design documents.
- **2.4.55.2** Pneumatic type actuators may be acceptable for steam control valves where required to meet the shut-off and torque requirements. BAS Project Consultant shall request permission from the U of T Project Team for the proposed application of pneumatically actuated valves.
- **2.4.55.3** Pneumatic type actuators are required for High Temperature Hot Water service.
- **2.4.55.4** BAS contractor is responsible for connecting to existing pneumatic system or supplying and installing pneumatic system where required to operate valves.
- **2.4.55.5** Actuator shall be motor driven type. Valve stem position shall be adjustable in increments of one (1%) percent or less of full stem travel.
- **2.4.55.6** Actuator shall have an integral self-locking gear train, mechanical travel stops and adjustable travel limit switches with electrically isolated contacts.
- **2.4.55.7** Actuator gear assembly shall be made of hard-anodized aluminum or steel or material of equivalent durability. No plastic components shall be acceptable.
- **2.4.55.8** Actuator shall be rated for continuous duty and have an operating voltage of 24 VAC, an input of 0 -10 VDC or 4- 20 mA control signal and provide a 0-10 VDC feedback.
- **2.4.55.9 NOTE:** No floating point actuators will be accepted.

- **2.4.55.10** Actuators on valves located in the outdoors shall have NEMA 4 enclosures.
- **2.4.55.11** Actuator motor shall be fully accessible for ease of maintenance.
- **2.4.55.12** Actuator shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head.
- **2.4.55.13** Actuator shall control against system maximum working pressures.
- 2.4.55.14 Actuator shall fail safe as indicated on the control drawings that form part of these contract documents. Provide spring return to de-energized position on loss of power and loss of control signal if so required by the sequences of operation. NOTE: No fail last position actuators will be accepted.
- **2.4.55.15** Actuator shall accept control signals compatible with the BAS analog or digital output subsystem as appropriate. The valve stem position shall be linearly related to the control signal.
- **2.4.55.16** Actuator shall have visual mechanical position indication, showing valve position.
- **2.4.55.17** Actuator shall operate the valve from the fully closed to the fully open position and vice versa in less than two minutes.
- **2.4.55.18** Actuator shall be constructed to withstand high shock and vibration without operations failure. Materials of construction shall be non-corroding.
- **2.4.55.19** All valve actuators for service of control valves larger than $\frac{3}{4}$ " or as approved by the UofT Project Team, shall be equipped with an integral position potentiometer or 0-10VDC feedback to indicate the stem position of the valve. All valve actuators shall have integral end position indicators.
- **2.4.55.20** Actuators shall have manual over-ride capability. The operator will be able to manually modulate valves located in mechanical rooms in the event of loss of power.
- **2.4.55.21** Actuator motor shall be fully accessible for ease of maintenance.
- **2.4.55.22** Approved Manufacturers: Belimo, Siemens Building Technologies, Johnson Controls Inc., Honeywell

2.4.56 Damper Actuators: Electric/Electronic

- **2.4.56.1** Unless otherwise specified the BAS Project Consultant shall design electric/electronic actuators for all dampers and shall meet, at minimum, the following requirements:
- **2.4.56.2** Damper actuators shall be selected as per manufacturer's recommendations with sufficient close-off to effectively seal the damper.
- **2.4.56.3** Modulating actuators shall provide smooth modulating control under design flow and pressure conditions.
- **2.4.56.4** Provide one actuator for each damper section. Damper actuators shall not be stacked.
- **2.4.56.5** Damper actuators shall fail as indicated on the control drawings that form part of these contract documents. Provide spring return to de-energized position on loss of power and loss of control signal if so required by the

- sequences of operation. **NOTE:** No fail-to-last position actuators will be accepted.
- **2.4.56.6** Actuator for modulating automatic dampers shall be rated for continuous duty and have an operating voltage of 24 VAC, an input of 0 -10 VDC or 4-20 mA control signal and provide a 0-10 VDC feedback.
- **2.4.56.7 NOTE:** No floating point actuators will be accepted.
- **2.4.56.8** Actuators for two position dampers shall be controlled by 24VAC, 24VDC power.
- **2.4.56.9** Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages
- **2.4.56.10** All actuators shall accept 25 mm diameter shaft directly, without the need for auxiliary adapters.
- **2.4.56.11** All actuators shall have self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "V" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
- **2.4.56.12** All actuators shall have an all metal housing made from die-cast aluminum.
- **2.4.56.13** All actuators must provide overload protection throughout the full range of rotation, enabling the actuator to detect a blockage in the damper and withstand a continuous stall condition without premature failure in performance.
- **2.4.56.14** All spring return actuators shall be capable of either clockwise or counter clockwise spring return fail-safe operation.
- **2.4.56.15** Stroke dampers from fully closed to fully open in accordance with the following:

Service	Timing Requirement
Two position normal	75 seconds
service	
Modulating normal	120 seconds
service	
Emergency service (stair	15 seconds
pressurization,	
smoke containment,	
Fail-safe etc.)	

2.4.56.16 A

ll actuators shall be equipped with a manual drive release mechanism and manual positioning mechanism in the absence of power.

- **2.4.56.17** Rated for operation at ambient temperatures of minus 40° C to 50° C.
- **2.4.56.18** All actuators shall provide an easily readable damper/actuator position indicator.
- **2.4.56.19** Actuators shall be quiet in operation such that noise from actuator operation is not detectable in any occupied spaces.

2.4.56.20 Approved Manufacturers: Belimo, Siemens Building Technologies, Johnson Controls, Honeywell.

The project consultant confirming that all the requirements in the Section 2.4 of this document have been incorporated in the project's Design Specification documentation.		
☐ YES, all the requirements in this section have been incorporated in the Design Specification. ☐ NO, the requirements in this section haven't been incorporated in the Design Specification. ☐ N/A the requirements in this section are not applicable for the project the DS.		
\square N/A, the requirements in this section are not applicable for the project the DS.		
Provide the explanation, if NO or N/A options are selected:		
The project consultant to provide the cross-reference between the sections in the Building Automation and Energy Systems Design Standard and the Project Design Specification:		
Building Automation and Energy Systems		
Design Standard		
Ex. 2.3	22.13	
	<u></u>	
CHECKLIST 10		
Date: Consulting Engineer:	Signature:	
Something Engineeri		

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PART 3 - EXECUTION

3.1 INSPECTION

- **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 BAS Project Consultant.
- **3.1.2** It is the responsibility of the BAS Project Consultant to ensure the site and system design criteria can be met and to bring to the attention of UofT Project Team any conflicts or discrepancies before proceeding.
- 3.1.3 It is the responsibility of the BAS Project Consultant to inspect the project documents and ensure all BAS equipment required to bring about the full intent of these Standards is included in their design. This includes all cabling, connections to the UofT LAN, LAN interface devices, network cabling between UofT LAN, switches and all BAS devices as required. The BAS Project Consultant shall coordinate with the UofT Project Team to ensure the design meets these Standards.
- **3.1.4** Arrange for Electrical Authority inspection of all electrical work. Arrange for a separate inspection of any field assembled electrical panels or systems that have not been preapproved by CSA/ULC. Submit the Certificate of Inspection and Product Approval Certificate with the as-built documentation.

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3.2 INSTALLATION OF CONTROL SYSTEM

- **3.2.1** Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
- **3.2.2** Install all controllers, cabinets, control devices and power supplies in readily accessible locations providing adequate ambient conditions for its specified application and to the Canadian Electrical Code.
- **3.2.3** Refer to additional requirements in other sections of this specification.
 - **3.2.3.1** Check installation in field to verify built to detailed design requirements including accepted Change Orders as per the Design Engineer.
 - **3.2.3.2** Verify and document with completed signed Calibration report all sensors and instruments installed, cross reference to Detailed Design requirements to verify process range capability
 - **3.2.3.3** Verify wiring integrity for each end device output to BAS Controller using service tool for existence and correctness as per Detailed Design, identify 100% of IP Addresses and BACnet Instance Numbers for existence and correctness.
 - **3.2.3.4** Verify all connections between BAS Controller and Patch Panels by using a cable test management tool with integrated recording and reporting capability.
 - **3.2.3.5** Verify all connections between Patch Panel and F&S Network Switch manually, documenting 100% of connections
 - 3.2.3.6 Using Service Tool loop test 100% of connections from F&S Network Switch to End Device verifying integrity of signal, response to commands, and Range of Process Control Tolerance. This requires visual confirmation at the End Device and at the Service Tool I Network Switch simultaneously.
 - **3.2.3.7** Verify operation of Un-interruptible Power Supply (UPS) at the F&S Network Switch I Panel Device.
 - 3.2.3.8 Using existing Enterprise Monitoring and Reporting System (EMRS) verify 100% acquisition of data to "System Graphic Screen" from End Devices for specified functionality simultaneously at both EMRS station and End Device locations in compliance with the BAS object naming convention, according to the project's BACNET Metamodel Definitions document provided by the University.
 - **3.2.3.9** Using existing Enterprise Monitoring And Reporting System (EMRS) verify integrity of Graphics HMI as specified in System Design
- **3.2.4** All electrical power supplies to the control devices & auxiliary components must have current protection. (Circuit breaker or fuse are acceptable).
- **3.2.5** An external fast-blow fuse must be installed to all powered input/output devices with a rating of slightly less than the maximum recommended manufacturer's current rating for the device.

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3.3 CONTROL PANELS, CONTROLLER QUANTITY AND LOCATION

- **3.3.1** Control panels shall consist of one or multiple controllers as required to meet requirements of the project and follow these Standards. Control panels shall be wall mounted within mechanical equipment rooms. In no case shall panels, other than terminal unit controllers, be located above ceilings. Control panels for lighting control may be located in the electrical equipment room served by the control panel on prior approval of UofT Project Team.
- **3.3.2** BAS Contractor shall extend power to the control panel from an acceptable power panel. If the control contractor wishes to further distribute panels to other locations, control contractor is responsible for extending power to that location by providing the required circuit breaker. Furthermore, the Project Consultant 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** It is the Project Consultant's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.
- **3.3.4** For rooftop AHUs, ERUs, etc., controllers rated for use outside the building envelope shall be mounted inside the unit casings. If adequate space is not available for installation of the controllers per the manufacturer's recommendations, they shall be installed in NEMA-4X enclosures adjacent to the unit served. For all other controllers serving rooftop equipment coordinate with UofT Project Team for control panel location, typically within the building envelope directly below equipment served in an accessible location.

3.4 CONTROLLERS FOR TERMINAL EQUIPMENT

- **3.4.1** For equipment located in the conditioned space, controllers shall be mounted inside the unit enclosure. Where sufficient mounting space is not available inside the unit enclosure, a control panel shall be installed above the drop ceiling, inside the room, as close to the room space sensor as possible. Coordinate with UofT Project Team to clarify acceptable mounting locations.
- **3.4.2** For equipment located above the drop ceiling, controllers shall be unit mounted. (Notify UofT Project Team if 1 m clearance in front of control panel has not or cannot be provided.) Provide adhesive backed ceiling labels, affixed to ceiling grid below all ceiling concealed controllers, affix to ceiling panel access door for solid ceilings.
- **3.4.3** Laminated control drawings, including system control schematics, sequences of operation and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

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3.5 UNINTERRUPTIBLE POWER SUPPLY & SURGE PROTECTION

- **3.5.1** The Project Consultant shall design any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCs operator interfaces, printers, routers and other hardware and interface devices. All equipment shall be capable of handling voltage variations above or below measured nominal value, with no effect on hardware, software, communications, and data storage, as per the electrical standards.
- **3.5.2** If failure occurs from surges and transients during the warranty period, then Contractor shall repair surge protection equipment and other equipment damaged by the failure at no cost to the UofT.
- **3.5.3** Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients.
- **3.5.4** Uninterruptible power supplies (UPS) shall supply power for the BC(s), repeater(s) and/or ASC(s)/AAD(s) that monitor or serve emergency and/or critical equipment, locations or points.
- **3.5.5** The dry contacts for monitoring the UPS(s) status shall be monitored by the BAS.
- **3.5.6** The UPS shall be equipped with a cord and plug and shall be plugged into a secure outlet. The outlet shall be connected via a dedicated BAS circuit to the building Normal/Emergency, Standby-Optional electrical panel, which may be the same outlet specified above, if applicable. The UPS is not to be hard wired.
- **3.5.7** Signage at the UPS plug-in location shall include the Electrical Panel Name and Breaker # with "This outlet for UPS Only".
- **3.5.8** The UPS and the related plug shall be enclosed if necessary where public access is possible.

3.6 INSTALLATION OF METERS AND RELATED DEVICES

- **3.6.1** Install sensor(s) in accordance with the manufacturers' recommendations to accurately sense the variables specified.
- **3.6.2** Flow metering installations shall in compliance with governing body regulations such as ISO, API, AGA and ANSI 2530/ASME Fluid Meters standards.
- **3.6.3** BAS Vendor is responsible for the supply and the installation of all devices, software, communication devices and power supplies to bring metered data to the EMRS.
- **3.6.4** BAS Vendor shall verify the communication of all metered data from the field level meter point to the EMRS is consistent, reliable and matches actual field measured data.
- **3.6.5** Mount sensors securely. Mountings shall be suitable for the environment within which the sensor operates.
- **3.6.6** Install sensors to properly sense the controlled medium.
- **3.6.7** Sensor locations shall be such that the instruments can be accessed for service and removal.
- **3.6.8** Sensors mounted on water lines shall have isolation valves that shall enable the sensor to be easily removed without the need to drain any lines or portions of lines.
- **3.6.9** Flow meters shall have 30 pipe diameters of straight pipe length upstream and 5 pipe diameters downstream of the flow sensing device or as per Manufacturers OEM instruction or as accepted and approved by UofT Project Team

- **3.6.10** A flow straighter shall be installed where sufficient upstream pipe length is not available.
- **3.6.11** When installed on Steam service the DP transmitter must be installed below the flow sensing device.
- **3.6.12** The DP transmitter must be equipped with a five-way manifold.
- **3.6.13** Where supplied, meter local display to be installed at a height that allows it to be read while standing on floor.
- **3.6.14** The display must have back light display capabilities.
- **3.6.15** On steam flow measurement a remote display may be permitted with approvals by U of T Project Team.
- **3.6.16** BAS Contractor to verify that the remote output reading matches the local display.
- 3.6.17 Differential pressure transmitter lead sensing lines shall be ½ inch OD x 0.035 316 Stainless steel and Swagelok fittings. The lead sensing lines must be sloped downward toward the transmitter at a minimum slope of 1 inch per foot. Minimize the length of the lead sensing lines. The lead sensing lines must have isolation valves at the flow sensing device.
- **3.6.18** The Lead sensing lines must have filling Tee's installed at the isolation valves. These Tee's should be installed in a Bull-nose fashion.
- **3.6.19** When installed on Steam service a blow-down must be added to the Lead sensing lines.
- **3.6.20** Display or Flow computer units shall operate in an environment of 0 ° C to 50 ° C
- **3.6.21** The meter must be installed in a clean pipeline, free from any foreign materials.
- **3.6.22** Condensate flow meters must have 10 pipe diameters upstream of the unit and 5 downstream to ensure proper flow through the meter. (Installation details to be shown in approved Mechanical Drawings.
- **3.6.23** A condensate flow meter shall be installed on the line leaving the Condensate tank returning back to the Central Steam Plant.

3.7 DEMOLITION AND REUSE OF EXISTING MATERIALS AND EQUIPMENT

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

- **3.7.1** Project Consultant shall assume that existing equipment that specifically is indicated to be reused is in good condition and is operable. Coordinate with UofT Project Team for clarification of reusable equipment. Project Consultant, during the course of work, shall inspect these devices and determine if any devices are in need of replacement or repair. Project Consultant shall prepare an itemized list of suggested repairs/replacement. This repair/replacement will be at the discretion of the UofT.
- **3.7.2** Existing wire, conduit, and control panel cabinets may be reused at the UofT Project Team discretion, but only if such materials or equipment comply with the applicable specification for new materials and equipment. Such materials shall not be reused if visibly damaged or otherwise unsuitable for the intended service.
- **3.7.3** Where such materials are reused, the BAS contractor's shop drawings shall reflect the existing wiring designation. If existing labeling is illegible or otherwise does not comply with the applicable specification for labeling, wiring runs shall be relabeled in accordance with the requirements specified elsewhere.
- **3.7.4** Existing pneumatic tubing and tubing conduit located between the existing BAS panels and the pneumatic operators may be reused as long as such materials comply with the applicable specification for new materials. Materials shall not be reused if visibly damaged or otherwise unsuitable for the intended service.
- **3.7.5** All pneumatic tubing to be reused shall be pressure tested and all leaks shall be repaired. All reused pneumatic tubing shall be purged with dry air or nitrogen.
- **3.7.6** The existing pneumatic main air supply system shall be modified as required and reused to serve existing pneumatic controls that are to remain, and shall be extended as necessary to serve new pneumatic controls. Where existing pneumatic controls are removed, main air piping shall be removed back to the point of connection to the main air supply which remains in use, and shall be capped or plugged.
- **3.7.7** Existing valves and dampers and their operators may be reused only when preapproved by UofT Project Team. Contractor shall lubricate all damper linkages of dampers being controlled under this project.
- **3.7.8** Other materials and equipment not specifically mentioned herein may be reused only if specifically allowed by indications on the drawings and approved by UofT Project Team.
- **3.7.9** For HVAC systems which are indicated to receive a new BAS, all existing materials and equipment associated with the existing pneumatic controls and BAS shall be removed unless otherwise specified or indicated to remain, or unless reused in accordance with the above requirements, except for the following:
 - **3.7.9.1** Conduit and electrical boxes (but not wiring within conduit) may remain in place if not reused (leave a pull line);

3.7.9.2 Inaccessible pneumatic tubing may remain in place if not reused. Tubing must be sealed and permanently labeled as "Abandoned in Place" and accepted by UofT Project Team.

3.7.9.3 Existing materials and equipment to be removed shall be removed subject to the requirements in paragraph "Sequence of Work". For HVAC systems, which are not to receive a new DDC BAS, the existing pneumatic control system shall remain fully functional.

3.8 SEQUENCE OF WORK FOR PNEUMATIC SYSTEMS CONVERSION

- **3.8.1** All work involving changeover of control functions from existing pneumatic control system to the new DDC BAS shall be performed in accordance with the following sequence in order to minimize the duration of equipment outages. The following descriptions are intended to indicate the sequence in which the work shall be performed, not to define fully the scope of the work.
- **3.8.2** All conversions from pneumatic controls to DDC must be completed with products and procedures that follow these Standards.
- **3.8.3** Install operator's terminal, peripherals, graphic software, and LAN prior to placing any equipment under the control of the new BAS.
- **3.8.4** Work which requires shutting down a pump motor, fan motor, or chiller shall be considered a utility shutdown and shall be subject to the restrictions specified in U of T's power outage protocol "**UofT Outage Notification Protocol**".
- **3.8.5** The following sequence applies to an individually controlled HVAC subsystem, such as an air handling unit. Only one such system shall be placed under manual control at any given time.
 - 3.8.5.1 Install controllers adjacent to (or within) existing control panel. Programming shall be complete (except for loading and debugging) prior to installation. Install all field devices, which do not require interruption of the existing control system.
 - **3.8.5.2** Install all conduit, wiring, and pneumatic tubing which does not require interruption of the existing control system.
 - **3.8.5.3** Remove existing controls including wiring, conduit, and tubing (except materials to be reused in accordance with provisions specified elsewhere) which must be removed to facilitate installation of new BAS materials and equipment.
 - **3.8.5.4** Remove existing digital control system points (if applicable). Install and calibrate remainder of new BAS materials and equipment for this subsystem. Load controller software. Connect controller(s) to LAN.
- **3.8.6** Perform all field testing and calibration that does not require connection of permanent pneumatic outputs.
- **3.8.7** Remove remaining existing pneumatic and digital control system materials and equipment (except materials to be reused in accordance with provisions specified elsewhere). All existing digital controls equipment for those subsystems that have not yet been converted shall remain intact, on-line, and fully functional.
- **3.8.8** Schedule work in University occupied spaces 10 working days in advance with the University's representative. Scheduling shall not be required for work in equipment rooms, electrical closets, and similar service areas.

3.9 CONTROL POWER SOURCE AND SUPPLY

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below:

- **3.9.1** Project Consultant shall design the extensions of all power source wiring required for operation of all equipment and devices provided in the BAS project.
- **3.9.2** All control panels shall be served by dedicated power circuits. BC control panels shall additionally be provided with external UPS power supplies to meet the requirements for BC power failure operation. Control panel shall be labeled with electrical panel & circuit source.
- **3.9.3** 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.
- **3.9.4** 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.
- **3.9.5** 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 of 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.
- **3.9.6** All device power sources and supplies must be labeled.

3.10 COORDINATION

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

- **3.10.1** Integrate and coordinate work under this section to controls and control devices provided or installed by others.
- **3.10.2** Coordinate access to and integration of the BAS onto the EMRS with UofT Project Team. Access to the F&S LAN is strictly controlled by UofT IT. UofT IT requires a minimum of three (3) days' notice for any LAN IP addresses or access. **Note:** No contractor switches or LAN extenders will be permitted without express and written approval by UofT IT.
- **3.10.3** Each supplier of control product to configure, program, start-up and commission that product to satisfy requirements of Sequence of Operation regardless of where within contract documents product is described or specified.
- **3.10.4** Resolve compatibility issues between control product provided under this section and those provided under other sections or divisions of this specification.

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3.11 PASSWORD PROTECTION

- **3.11.1** Password protection is critical for authorized and traceable access. Multiple-level password access protection shall be provided to allow the U of T IT and EMRS Administrator to limit workstation control, display and database manipulation capabilities as they deem appropriate for each user, based upon an assigned user name with a unique password.
- **3.11.2** All passwords for the BAS system including the manufacturer level passwords for the systems provided under this project shall be provided to the UofT Project Team by the BAS contractor.
- **3.11.3** Passwords shall restrict access to all Control Units.
- **3.11.4** Each user name shall be assigned to a discrete access level. A minimum of five levels of access shall be supported. Alternately, a comprehensive list of accessibility/functionality items shall be provided, to be enabled or disabled for each user.
- **3.11.5** A maximum of 30 user names per Area shall be supported and programmed per the University's direction.
- **3.11.6** Operators and Control Technicians shall be able to perform only those commands available for the access level assigned to their user name.
- **3.11.7** User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators and Control Technicians from inadvertently leaving interface device software on-line.

3.12 PASSWORD SETUP

3.12.1 Set up the following password levels to include the specified capabilities:

1. Level 1: (UofT - IT, EMRS Administrator)

- a) Modify graphic software
- b) View, add, change and delete user names, passwords, password levels
- b) All unrestricted system capabilities including all supervisory devices.
- c) Configure system software
- d) Modify control unit programs
- e) Any modifications to control units
- c) All Administrator rights.

2. Level 2 (UofT Control Technicians, Area Managers)

- a) Access to all Campus Areas
- b) All unrestricted system capabilities including all supervisory devices.
- c) Configure system software
- d) Modify control unit programs
- e) Any modifications to control units programing must be requested in writing through the UofT Change request process.

3. Level 3: (Building Operator Leadhand)

- a) Access only to their assigned Area
- b) Override output points
- c) Change setpoints

- d) Change equipment schedules
- e) Acknowledge alarms
- f) Unrestricted access for viewing or modifying Building Operators user names & passwords.
- g) Exit BAS software to use third party programs

4. Level 4: (Building Operator)

- a) Access only to their assigned Area
- b) Override output points
- c) Change setpoints
- d) Change equipment schedules
- e) Acknowledge alarms

5. Level 5: (Read Only, Guest)

- a) Display all graphic data
- b) Trend point data

3.13 POINT NOMENCLATURE

3.13.1 Point nomenclature shall be consistent and approved by U of T Project Team. The point name shall uniquely identify the point within the EMRS and describe the point function. The name will include point location, category, equipment type, space type and point type. Sample naming as follows:

BUILDINGNUMBER_SYSTEMNAME_ DEVICENAME_ENGUNITS

For example:

042_AHU1_SASPT1_TTT degC

- **3.13.2** U of T Building & Point Naming Convention List
 - **3.13.2.1** See Section 3.22, Figure 7 for Building numbers, System and Device name list.

3.14 POINT OVERRIDE

- **3.14.1** Each displayed point shall be individually enabled/disabled to allow mouse driven override of digital points or changing of analog points.
- **3.14.2 NOTE:** These override points will have a timed out function (programmable). Such overrides or changes shall occur in the control unit, not just in the EMRS system. The graphic point override feature shall be subject to password level protection. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded PINK color. See Section 3.21, FIGURE 2.
- **3.14.3** The alarm message shall include the operator's user ID. A list of points that are currently in an override state shall be available through menu selection.
- **3.14.4** All override points must be limited to a selectable allowable time up to a maximum of 24 hrs. When the overridden point has timed out, the point will reset back to a default setting and will generate an alarm.
- **3.14.5** Only BACNET Manual Operator Override function is allowed with the Bacnet Priority 8. Any vendor specific override functionalities that use non Bacnet compliant functions are not acceptable.

3.15 GRAPHIC SCREENS

- **3.15.1** Refer to Section 3.22 Diagrams and Figures for samples of interactive graphic designs. All graphics will be configured for the EMRS and approved by the U of T Project Team.
- **3.15.2** Floor Plan Screens: The contract document drawings will be made available to the UofT Project Team in AutoCAD format upon request. These drawings may be used only for developing backgrounds for specified graphic screens.
- **3.15.3** Provide main page graphic that can be used to identify and link to all graphics supplied.
- **3.15.4** Provide graphic floor plan screens for each floor of the building. Indicate the location of all equipment that is not located on the equipment room screens. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone. Mechanical floor plan drawings will be made available to the contractor upon request for the purpose of determining zone boundaries. 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.
- **3.15.5** 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.
- **3.15.6** 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.
- **3.15.7** Provide a graphic site plan with links to and from each building plan.
- 3.15.8 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. 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.
- **3.15.9** 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.
- **3.15.10**Provide a graphic screen for each zone. Provide links to graphic system schematic screens of air handling units that serve the corresponding zone.
- **3.15.11**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.
- 3.15.12Link screens for heating and cooling system graphics to utility history reports showing

current and monthly electric uses, demands, peak values, and other pertinent values.

3.15.13 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 and digital values that are in an 'alarm' condition in a red colour. See section 3.18, Figure 1 for Alarm symbols.

3.16 DYNAMIC SYMBOLS:

3.16.1 Provide a selection of standard symbols that change in appearance based on the value of an associated point. See Section 3.18, Figures 1,2,3,4 & 5.

3.16.1.1 Point Status Color:

Graphic presentations shall indicate different colors for different point statuses (e.g. for ALARM and OVERRIDE STATUS - green = normal, red = Critical Alarm, yellow = non-Critical Alarm) and pink = operator override)

3.16.1.2 Analog Symbol:

Provide a symbol that represents the value of an analog point as an engineering units and/or linear bar graph.

3.16.1.3 Digital Symbol:

Provide symbols such as switches, pilot lights, rotating fan wheels, etc., to represent the value of digital input and output points.

3.16.1.4 The Project Consultant shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components, mechanical system components, complete mechanical systems and electrical symbols. At a minimum provide all symbols used by the graphics required by this solicitation. Submitted to the U of T Project Team for approvals.

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3.17 ACCEPTANCE TEST

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

- **3.17.1** When EMRS Integration and Commissioning Process has been completed satisfactorily, the UofT Project Team will give approval for commencement of the Acceptance Test.
- **3.17.2** Notify UofT Project Team in writing 2 weeks prior to the testing date.
- **3.17.3** Furnish a new operator's log book to building operators.
- 3.17.4 The Acceptance Test period shall be 21 days. Visit the site each morning, Monday to Friday, to review the BAS operation and the building operators log book which contains records of all problems experienced by the building operators, the point object name and value and time and date of failure, and time of return to service. During the first 14 days of the acceptance test, any operational failures due to malfunction of wiring, controllers or Operator Interfaces, shall designate a restart to testing for 21 days. Any failure of control devices shall be corrected and the acceptance test shall continue from the date the failure has been corrected. During the last 7 days of testing, no failures of any kind will be accepted, or the last 7 days shall be repeated.
- **3.17.5** The BAS shall not be accepted or handed over until the Acceptance Test is successfully completed.
- **3.17.6** Verify the overall networked system performs as specified.
- **3.17.7** Commissioning is to be in coordination with U of T Project Team Commissioning Standards.
- **3.17.8** Carry out end-to-end checks for all control points, verifying their proper operation. End-to-end checks are defined as VISUAL confirmation that an input or output signal from the DDC system results in correct operation of physical system components, not assumed operation as implied by output status indicated on system interface screens or graphics. Produce documentation indicating the date and results of all end-to-end checks, including calibration factors entered.
- **3.17.9** Subsystems not controlled electronically shall also be tested and commissioned.
- **3.17.10** At the successful completion of the Acceptance Test, provide a certificate of completion.

3.18 INSTRUCTION AND TRAINING

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

- **3.18.1** The training objectives and deliveries must comply with the Section 3.20.5 of this document
- **3.18.2** The level of training required will depend on the scale of the BAS Project. Training level and number of days for the following sections to be fully defined by UofT Project Team.
- **3.18.3** Provide a qualified instructor (or instructors) with five years minimum field experience with the installation and programming of the project's BAS DDC systems.
- **3.18.4** Provide instruction during the BAS installation. This instruction shall include: identification of devices, power sources, conduit and wire installation, the operation of controlled devices and how they interface with the mechanical systems.
- **3.18.5** Provide additional days of instruction that shall cover the operation and maintenance of the BAS systems. The instruction shall be conducted in the building and audio/video recorded on a digital media with the appropriate reviewable quality by the Project Contractor. Submit training course outline for review by the UofT Project Team before completion of the BAS and before instruction period commences.
- **3.18.6** The components of the training must comply with the Section 3.20.5.2 (Training Plan) of this document.
- **3.18.7** Any maintenance performed by the U of T personnel shall not cause the warranty on the components to be voided or amended in any way.
- **3.18.8** Provide an additional three (3) days of training that may be scheduled up to six months after BAS Acceptance. UofT Team will advise the BAS Project Consultant of the training content required.
- **3.18.9** A training day shall occur during normal working hours, last no longer than 7.5 hours and include a one-hour break for lunch and two additional 15-minute breaks.

3.19 EMRS INTEGRATION WITH NON-BACNET COMPLIANT COMPONENTS

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

3.19.1 PURPOSE AND DEFINITIONS

The purpose is to describe the functional requirements for the BACNET protocol data acquisition (DAQ) and data share between the EMRS, BAS Direct Digital Controllers (B-BC, B-AAC) and the embedded non-compliant BACNET controls components.

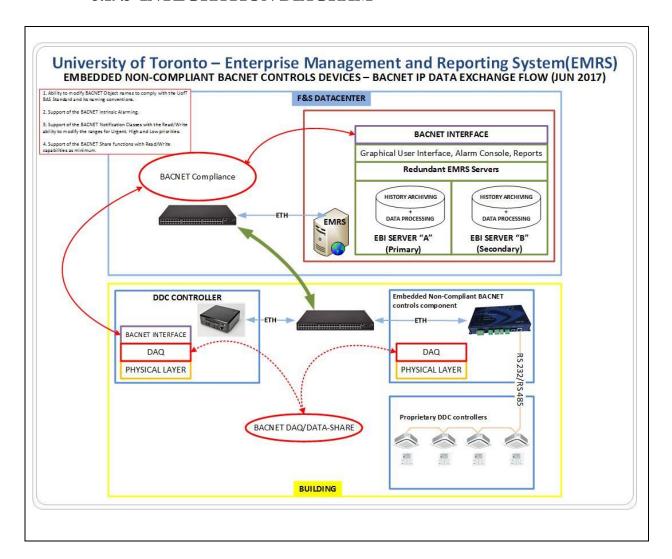
These may include the Variable Refrigerant Flow (VRF) devices, chillers, boilers, humidifiers, Variable Speed Drives, meters interfaces, lighting controls, weather stations, flow stations, gas monitors, fume hoods and lab controls, etc. Provide main page graphic that can be used to identify and link to all graphics supplied.

- **3.19.1.1** The BACNET compliance level is determined by the capabilities of the BACNET device to support the following minimum requirements:
 - Ability to modify BACNET Object names to comply with the UofT BAS Standard and its naming conventions.
 - Support of the BACNET Intrinsic Alarming.
 - Support of the BACNET Notification Classes with the Read/Write ability to modify the ranges for Urgent, High and Low priorities.
 - Support of the BACNET Share functions with Read/Write capabilities as minimum.
- **3.19.1.2** The standard implementation requires the approved BAS Controls vendor (Siemens, Honeywell or Johnson Controls) to implement the solution where the integration with the embedded non-compliant BACNET components is done directly through B-BC/B-AAC.
- **3.19.1.3** All the BACNET object mapping, BACNET alarm management and BACNET DAQ algorithms are solely created within the vendor's approved B-BC or B-AAC controllers.

3.19.2 IMPLEMENTATION

- **3.19.2.1** Direct integration between EMRS and embedded non-compliant BACNET controls components is not allowed.
- **3.19.2.2** It is full responsibility of the BAS vendor to identify the compliance level of the embedded non-compliant BACNET controls components.
- **3.19.2.3** The compliance level must be approved by the UofT BAS Project Team
- 3.19.2.4 The non-compliant BACNET controls component that is serving a critical mechanical system(s) must have implemented the fully functional and alarmed Device Status heartbeat and watchdog algorithm. This will allow to monitor that status of the non-compliant BACNET controls component. This must be implemented for the critical BAS applications like chillers, fume hoods, labs identified in written by UofT Project Team.

3.19.3 INTEGRATION DIAGRAM



The project consultant confirming that all the requirements in the Section 3.19 of this document have been incorporated in the project's Design Specification documentation.									
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 									
IN/A, the requirements in this section are not ap	opincable for the project the DS.								
Provide the explanation, if NO or N/A options are	re selected:								
The project consultant to provide the cross-re Automation and Energy Systems Design Standard	eference between the sections in the Building								
Building Automation and Energy Systems									
Design Standard									
Ex. 2.3	22.13								
	<u></u>								
CHECKLIST 11									
Date: Consulting Engineer:	Signature:								
2									

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3.20 EMRS INTEGRATION COMMISSIONING PROCESS

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

3.20.1 PURPOSE AND DEFINITIONS

The Commissioning Process for EMRS Integration is intended to direct the commissioning activity of integrating a building level BAS to the EMRS for all new, expanded or renovated systems.

This document is intended to provide the guideline to establish each stage of the EMRS integration process, its prerequisites, deliverables and the responsibility matrix to ensure the following:

- During the project handover phase, UofT F&S has the ability to operate and to monitor the interfaced equipment through the temporary vendor specific standalone BAS Workstation with the capabilities to provide the remote alarm notifications.
- Upon the project completion, UofT F&S has the operational and monitoring ability of the interfaced BAS equipment.

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3.20.3 STANDARDS

- **3.20.3.1** The following standards shall be referenced in conjunction with this document.
 - 3.20.3.1.1 Left <blank>
 - 3.20.3.1.2 University of Toronto –Commissioning Process, Overall Building Commissioning:

http://www.fs.utoronto.ca/wp-content/uploads/standards/commissioning/BuildingCommissioningProcess.pdf

- **3.20.3.2** Comply with rules and regulations of codes and ordinances of local, provincial, and federal authorities, such codes and ordinances, when more restrictive, take precedence over the Contract Documents.
- **3.20.3.3** The Commissioning Process Roles and Responsibilities Matrix is provided under the Section 3.24 of this document.

3.20.4 PROCEDURE

3.20.4.1 General

- 3.20.4.1.1 The process has been described in stages in which required deliverables and responsibilities throughout the project development and implementation are defined. To ensure a smooth transition through the sequential stages through the project it is necessary that each stage's deliverables be submitted and accepted prior to entering the next stage.
- 3.20.4.1.2 The Cx Authority will be responsible to coordinate with all stakeholders to develop the Cx schedule that will incorporate these milestones and establish timelines as agreed by all stakeholders.

3.20.4.2 Design /Pre Tender Stage

- 3.20.4.2.1 The Basis of Design will be a document provided by the Design Engineer to the UOT Project Team for review. Refer to the Overall Building Commissioning Process Standard.
- 3.20.4.2.2 F&S Project Team will provide the Cx Team with estimates of time and cost to execute the integration of the BAS systems to the EMRS. The estimate is intended to provide the Cx team with approximate timelines required for F&S IT to complete various tasks.

3.20.4.3 Construction Stage

3.20.4.3.1 This stage in the process shall be completed prior to the occupancy or the mechanical building systems handover, whichever comes first.

- 3.20.4.3.2 The BAS contractor will provide the Shop drawing documentation to the Design Engineer for review. The Shop drawings must comply with section 1.11 of the UOT Building Automation Design standards.
- 3.20.4.3.3 Shop drawings reviewed by both Design engineer and Cx authority shall be submitted to F&S Project team for review and commencement of EMRS graphics. Only shop drawings marked as "Reviewed as noted" or "Approved" shall be submitted to the F&S project team. F&S Project team will return their comments for Design Engineer review/comments and incorporation in the final review of the Shop Drawings returned to the Project Consultant. The project shall allow in the schedule enough time for this review cycle to occur.
 - 3.20.4.3.3.1 The CxA shall review the documents from the commission ability standpoint. In their review, they should clearly state that the shop drawings have all required information for commissioning of the BAS system including testing all sequences of operation.
 - 3.20.4.3.3.2 The CxA shall submit their comments in editable document.
 - 3.20.4.3.3.3 The Design Engineer shall provide responses to each of the CxA comments in the editable document. This document shall be provided to F&S Project team with reviewed shop drawings for their record.
- 3.20.4.3.4 Submit the Approved/Reviewed as noted status BAS shop drawing to F&S Project team for review and commencing generation of EMRS graphics.
- 3.20.4.3.5 The Cx Authority will provide Functional Performance test scripts /BAS system Acceptance procedures to the Cx Team for review through an updated Cx Plan.
- 3.20.4.3.6 Acceptance procedure

3.20.4.3.6.1 The Cx Authority shall complete:

3.20.4.3.6.1.1	All fun	ctiona	ıl performan	ice test	s as per C	x Plan and
	submits	s any o	discrepancie	s or iss	sues noted	through an
	issues	log	supported	with	concern,	corrective
	measur	es, an	d responsibi	ilities.	Submit the	issues log
	to the F	&S P	roject team.			

- 3.20.4.3.6.1.2 Ensure that all field devices, including sensors, final control elements installed as per approved control schematics. Any discrepancies should be marked up and submitted as part of the Field Cx documentation.
- 3.20.4.3.6.1.3 Ensure all Controllers, B-BC, B-ASC, B-AAC installed, powered up and commissioned as per the approved BAS shop drawing. Any discrepancies

should be marked up and submitted as part of the

	Field Cx documentation.
3.20.4.3.6.1.4	Ensure all required physical networking are in
	compliance to Section 3.21 of the UOT Building
	Automation Design standards. Review and verify all
	Networking cable checklists and Fluke test reports
	submitted by the contractor. Any discrepancies
	should be marked up and submitted as part of the
	Field Cx documentation.
3.20.4.3.6.1.5	Ensure all graphical representations of systems are
	provided on the temporary vendor specific
	standalone BAS Workstation with the contractor's
	temporary installed Graphical User Interface in the
	building. Provisions of all required alarms, trends,
	monitoring and control points (physical & virtual)
	must be provided and verified by the CxA on the
	Graphical user interface (GUI) provided by the BAS
	contractor. Screenshots of the GUI pages should be
	included as a part of the Field Cx Documentation to
	aid in the development of EMRS graphics
3.20.4.3.6.1.6	Ensure that the alarms notifications for the
	predefined and approved critical control
	objects/points are being sent to the predefined list of
	the alarm recipients from the BAS workstation. The
	BAS vendor must supply its own dedicated
	temporary communication gateway and/or a modem
	device for the internet connectivity along with the
	SMTP service that is properly and securely
	configured and functional.
3.20.4.3.6.1.7	Ensure that all the Bacnet Analog Inputs and Outputs
0.200.0.1.,	have properly configured Change of Value properties
	as defined in the Section 2.3.2.24 of this document.
3.20.4.3.6.1.8	Ensure all systems functional test forms after
3.20.1.3.0.1.0	completion must be submitted as part of the Field Cx
	documentation.
3.20.4.3.6.1.9	Ensure that the EMRS Bacnet Compliance Test
5.205.0.1.7	Readiness form is submitted based on the following
	template:
	winpiace.

EMRS Bacnet Compliance Test Readiness Form							
BAS Controls Contractor: Johnson Controls (JCI) Siemens (SBT) Honeywell (HBS)							
BAS Controls Contractor Team,							
We are in the preparation phase for the EMRS Bacnet Compliance Testing.							
Below is the list of project(s) and the most current submittal of the mandatory documentation.							
List of project(s): <insert identification="" project="" uoft=""> ex. P001-19-123 Main Building BAS Retrofit)</insert>							

As-Built Drawings – Network Architecture:

To be provided for all projects by BAS Controls Contractor. All drawings should have some references to the project numbers for the effective identification. The final markup drawings that reflects the completed state of the project are also acceptable.

The network architecture drawing is sufficient to show the B-BC and ASC/AAC riser for each B-BC. For the ASC/AAC architecture, the device count and traditional ASC/AAC schedule is sufficient, if exists.

EMRS Bacnet Implementation Metafile:

<insert the reference to the EMRS Bacnet Implementation Metafile> , ex. P001-19-123 Main
Building BAS Retrofit EMRS_BACNET_Implementation_Requirements_v3.0_05SEP2018.xlsx
(attached)

Wiring Installation Qualification Document:

<insert the reference to the Wiring Installation Qualification document based on the template listed here:

https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Wiring Installation Qualification Form.docx

IMPORTANT NOTE:

The attached documents must be reviewed by BAS Controls Contractor team as the documents will be used for the EMRS Bacnet Compliance Testing. Since all the information was shared, it is expected that the accuracy of the documentation will match the current on site installation. It is the responsibility of the BAS Controls Contractor to provide the proper information.

Any discrepancy between the documentation and the actual status during the compliance test will be flagged as FAILED.

ACTIONS REQUIRED:

- 1. BAS Controls Contractor to provide the as-built drawings or the final markup drawings that reflects the completed state of the projects. The network architecture drawings is sufficient to show the B-BC and AAC/ASC device count and the .
- 2. BAS Controls Contractor to provide the final confirmation that the projects are Network Ready and EMRS Ready.
 - a. Network Ready YES --- NO
 - i. IP device can be pinged from the properly labeled patch panel based on the document: < Wiring Installation Qualification Document >
 - b. EMRS Ready YES --- NO
 - i. B-BC and ASC/AAC are configured with the Bacnet Instance numbers and Bacnet Object names based on the document: < EMRS Bacnet Implementation Metafile >
 - B-BC has properly defined Alarm Notification Classes based on the UofT BAS Standard
 - iii. B-BC and ASC/AAC have properly configured Bacnet Change of Value properties for all Analog Inputs and Analog Outputs
- 3. BAS Controls Contractor to provide specific report "EMRS Bacnet Compliance Test Readiness Form.docx" based on the template listed here:

 https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/EMRS BACnet Compliance
 Test Readiness Form.docx
- 4. BAS Controls Contractor to provide specific report "Project Points List EMRS Submittal Form.xlsx" based on the template listed here:

 https://www.fs.utoronto.ca/wp-content/uploads/standards/bas/Project Points List EMRS Submittal Form.xlsx
- 5. UofT F&S IT: On site EMRS Compliance Testing (Total of # B-BC controller) expected completion: up to 5 business days following EMRS Ready report
- 6. UofT F&S IT: Final Report (pending on the test results) expected completion: up to 5 business days following EMRS Ready report
- 7. UofT F&S IT : EMRS Integration (alarms, history trends) expected completion: up to 5 business days following the Final Report
- 8. UofT F&S IT : EMRS Integration GUI (pending the final commissioning report) expected completion: up to 6 weeks following the EMRS Integration

Verification of "As Built" versus "Detailed Design Requirement" form is 3.20.4.3.6.1.10 submitted based on the following template: Table identifying "Detailed Design Requirement" and corresponding "As 3.20.4.3.6.1.10.1 Built" found in the field with sign off by the Commissioning Authority. Calibration certificate of end devices requiring calibration that identifies 3.20.4.3.6.1.10.2 the device 3.20.4.3.6.1.10.3 Calibration Tolerance limits (CTL) and the comparison of the CTL to the Process Calibration Tolerance Limits (PCTL) tabulated and signed off by the Commissioning Authority. 3.20.4.3.6.1.10.4 Documentation of wiring used and the documented 100% verification of individual connections between the End Devices to the BAS Controller identifying individual IP Addresses and BACnet Instance Numbers for existence and correctness, tabulated and individually signed off by the Contractor 3.20.4.3.6.1.10.5 Documentation of the connections between the BAS Controller and the BAS Patch Panel identifying the individual End Device, BAS Controller and BAS Patch Panel connection location, tabulated and individually signed off by the Contractor. Documentation of the individual connections between the BAS Patch 3.20.4.3.6.1.10.6 Panel and the Network Switch tabulating all connections identifying individual BAS Patch Panel connection ports and F&S Network Switch connection ports, signed off by the University of Toronto (Central IT). Documentation of loop test of 100% connections from F&S Network 3.20.4.3.6.1.10.7 Switch to End Device, tabulated to document integrity of signal and demonstrated Range of End Device process control capabilities, signed off by University of Toronto (IT), Contractor and Commissioning Authority. 3.20.4.3.6.1.10.8 Document capability of Un-interruptible Power Source (UPS) for operation and capacity, sign off by Contractor. 3.20.4.3.6.1.10.9 Document Graphics delivered to the Human Machine Interface (HMI) to Detailed Design Requirement with tabulated signoff and signed screen shots by the University of Toronto (IT), Contractor and Commissioning Authority. All above described documentation will be collated in order as listed 3.20.4.3.6.1.10.10 above into a bound document and signed off by the Contractor, University of Toronto (IT) and the Commissioning Authority with a preface acceptance covering letter.

3.20.4.3.6.2	All Field Cx documentation and related test sheets shall be
	provided to F&S Project team, (preferably system wise) to
	commence verification and integration of the installed BAS
	system to the EMRS within 1 week after Cx Authority has
	completed their onsite static and functional verifications.

- 3.20.4.3.6.3 Upon receipt of the Installation Checklist document based on Section 3.21 of the Wiring Requirements and the written notice that includes EMRS BACNET Compliance Test Readiness form (3.20.4.6.3.1.8), F&S IT will conduct an onsite visit to carry out the following tasks:
 - 3.20.4.3.6.3.1 Verification of the Installation Checklist prior the site visit.
 - 3.20.4.3.6.3.2 Site visit with the visual verification of the Installation Checklist.
 - 3.20.4.3.6.3.3 Installation qualification of the BACnet compliance of the BAS DDC components. Read/write access, naming convention, alarm notifications.
- 3.20.4.3.6.4 Upon completion, a set of verification documents for the UOT Building Automation Design standards compliance, BACnet integration compliance, and network wiring compliance shall be provided.
- 3.20.4.3.6.5 The CxA shall coordinate with the contractor the Training of Building Engineers, and the Control and Automation staff. The training shall be structured to align with the requirements as provided in section 3.20.5 of this document. Delivering training modules A, B and C on a functional system are mandatory prior to the project reaching the mechanical building systems handover. Refer to section 3.20.5.2 of this document.

3.20.4.4 EMRS Compliance Testing Stage

- 3.20.4.4.1 This phase can be initiated only after deliverables related to 3.20.4.3.6 have been submitted in the single submission package and reviewed by F&S. Partial submissions and/or incomplete documentation sets are not acceptable.
- 3.20.4.4.2 The intent is to reduce the modification of tag references of points that are populated on the EMRS in the following phase.
- 3.20.4.4.3 This phase includes multiple testing procedures performed by F&S to ensure that the physical installation and the DDC software configuration complies with the UofT BAS Standard.
- 3.20.4.4.4 This phase includes the EMRS database design in order to create the real-time data acquisition. This includes the following:
 - 3.20.4.4.4.1 Auto-discovery of all the BACnet objects between the DDC field controllers and EMRS. This will create the actual licensing cost model that is mentioned in the Design/Pre-Tender Stage section 3.20.4.2.2 of this document.
 - 3.20.4.4.4.2 Verification of the naming convention and BACnet compliance.
 - 3.20.4.4.4.3 Download of all compliant BACnet Objects to the online database and the initial start of the historical data collection and the ability of EMRS to send out the alarm notifications to the existing list of recipients.
- 3.20.4.4.5 Upon completion of this phase a fully programmed EMRS for the real-time data acquisition with the ability of the EMRS operators to collect the historical data for trending and the EMRS operators' ability to receive the alarm notifications.

3.20.4.5 EMRS Graphical User Interface Programming Stage

- 3.20.4.5.1 This phase includes the programming of the EMRS Graphical User Interface (GUI) with dynamic data.
- 3.20.4.5.2 Upon completion of this stage, Training Module D shall be conducted to all UOT Operational staff.
- 3.20.4.5.3 The operators and the Cx Authority can then use the developed programmed set of the EMRS Graphical User Interface.
- 3.20.4.5.4 Upon completion of EMRS GUI, Cx Authority will complete necessary GUI Functional verifications on the EMRS and provide review report to F&S Project team.
- 3.20.4.5.5 Cx Authority will also collect the required information to develop a Systems Manual to the F&S Project team for review and onward submission to Building Operations.
- 3.20.4.5.6 The BAS contractor's temporary GUI database backup will be provided to F&S Project Team and related hardware will be decommissioned from the network.

3.20.4.6 Final Tune Up Stage

20.4.0 Fillal	Tune Up Stage
3.20.4.6.1	Upon completion and availability of the final set of the as-built
	drawings, final tuning of the EMRS GUI can commence by F&S
	IT.
3.20.4.6.2	Updated As built as a result of final tune-up will be submitted by
	the BAS contractor to Cx Authority and Design Engineer for
	review.
3.20.4.6.3	The final Operation and Maintenance Manual will be developed
	following section 1.11.12 of the UOT Building Automation
	Design standards.
3.20.4.6.4	Cx Authority will provide an assimilated Cx report, which will
	include all field Cx documentation and certificate of completion
	and handover as per Overall Building Commissioning standard.

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3.20.5 TRAINING

3.20.5.1 General

- 3.20.5.1.1 This section describes the Structure of the training requirements for the UofT Operations Staff. It consists of four modules that are to be conducted at two stages of the EMRS Integration Process. The CxA will develop a course outline along with the contractor using the training plan structure described below and include training dates in Cx Schedule.
- 3.20.5.1.2 Stage 1 which includes Modules A, B and C is a prerequisite for occupancy and/or the mechanical building systems handover.
- 3.20.5.1.3 Stage 2 which include Modules D can be subsequent to the EMRS GUI programming stage, described in section 3.20.4.5.

3.20.5.2 Training Plan

Module A: Operation Training Part I

- 1. Review the as building control drawing.
- 2. Review list of control system components.
- 3. Review list of points and objects.
- 4. Review device and Network Communication Architecture
- 5. A walk-through of the mechanical system and installed DDC components (controllers, valves, dampers, sensors, etc.).
- 6. A discussion of the components and functions at each DDC panel
- 7. Operational use of Portable operator's terminal.

Attendees: Building Engineers, Automation and Control

Trainer: BAS Vendor's Specialist Witness: Commissioning Agent

Module B: Operations Training Part II (via temporary workstation)

- 1. Review sequence of operations, control functions and alarm functions.
- 2. Cover logging –in and navigating the system graphics.
- 3. Modifying set points.
- 4. Event management and scheduling.
- 5. Override control devices capabilities
- 6. Alarm capabilities and acknowledge protocols.
- 7. Troubleshooting strategies.
- 8. Trends set up.

Attendees: Building Engineers, Automation and Control

Trainer: BAS Vendor's Specialist Witness: Commissioning Agent

Module C: Servicing & Programming DDC Training

- 1. BACnet fundamentals (objects, services, addressing) and how/where they are used in this project.
- 2. Modifying and downloading control program changes.
- 3. Creating, editing and viewing alarms.
- 4. Backing-up and restoring programming and database modification.
- 5. Adding and removing network devices.
- 6. System malfunction diagnostics and maintenance.
- 7. Troubleshooting hardware errors.
- 8. Custom application programming software.
- 9. Point objects addressing and commanding.
- 10. Custom Reporting.
- 11. Review of customized project specific control logic used in the DDC programs

Attendees: Control Techs

Trainer: BAS Vendor's Specialist Witness: Commissioning Agent

Module D: Operations Training Part II (through EMRS)

- 1. Review sequence of operations, control functions and alarm functions specific to the project
- 2. EMRS refresher and building specific;
 - a. Cover logging –in and navigating the system graphics.
 - b. Modifying set points.
 - c. Event management and scheduling.
 - d. Override control devices capabilities.
 - e. Alarm capabilities and acknowledge protocols.
 - f. Troubleshooting strategies.
 - g. Trends set up.

Attendees: Building Engineers, Automation and Control

Trainer: UofT F&S – EMRS Specialist, BAS Vendor's Specialist

Witness: Commissioning Agent

3.20.6 Cx - DELIVERABLES CHECKLIST

The document posted <u>HERE</u> should be used to provide status to the Project Team in reference to the overall commissioning processes and tasks along with the

responsibilities matrix.

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The project consultant confirming that all the re- have been incorporated in the project's Design Sp								
 □ YES, all the requirements in this section have been incorporated in the Design Specification. □ NO, the requirements in this section haven't been incorporated in the Design Specification. □ N/A, the requirements in this section are not applicable for the project the DS. 								
Provide the explanation, if NO or N/A options ar	e selected:							
The project consultant to provide the cross-re Automation and Energy Systems Design Standard								
Building Automation and Energy Systems	Project Design Specification							
Design Standard Ex. 2.3	22.13							
CHECKLIST 12 Date: Consulting Engineer:	Signature:							

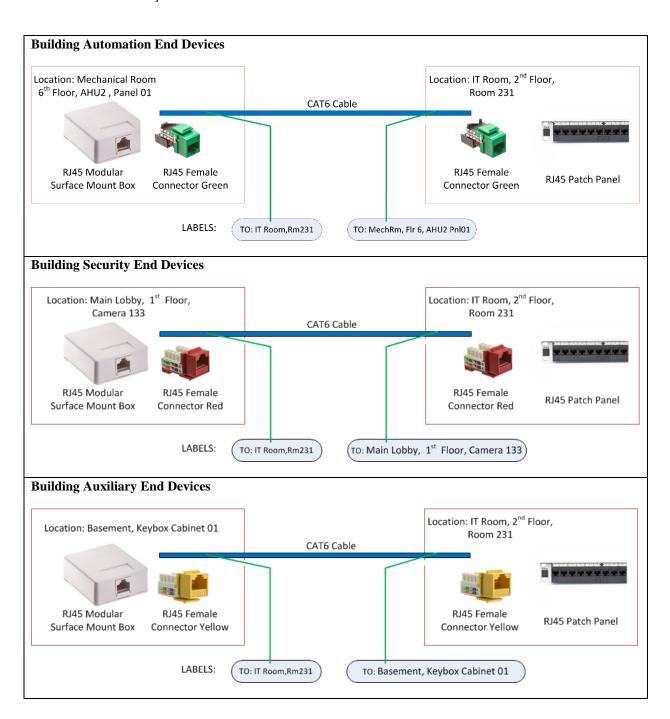
This page left intentionally BLANK for the additional comments.

3.21 EMRS BACNET COMPLIANCE TEST AND WIRING REQUIREMENTS

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

The following are the mandatory wiring requirements for the physical layer networking:

1. The CAT6 cable must be labeled on both ends with the following label syntax: TO [name of the location].



2. The CAT6 cable must be terminated on both ends with the RJ45 Female Modular connector as per the pictures below.



3. The RJ45 connector must be fully compliant with the patch panel and it is the installer's responsibility to use the RJ45 connector that properly fits the patch panel.

3.21.1 Wiring Installation Requirements

Device Name	Fluke Report Cable ID	Digital Picture(s) of the device with the wall module Label:	Digital Picture(s) of the device cable label Label:	Digital Picture(s) of the patch panel module Label:	Digital Picture(s) of the patch panel cable label Label:	Date / Initials
EXAMPLE: 070_DDC03	070_DDC03	Label: TO: Basement IT Room 44	Label: TO: Basement IT Room 44 Label: TO: Basement IT Room 44	Label: SIEMENS BAS	To: MechRm20, Basement, HTG/CLG 111DDCR2 Label: TO: Mech Rm20, Basement, HTG/CLG 111DDC02	01-MAR-2017, JS

IMPORTANT NOTE: It is a full responsibility of the submitter that the pictures are in high resolution, properly formatted and fully readable. The receiver of the document will decline improperly submitted documents.

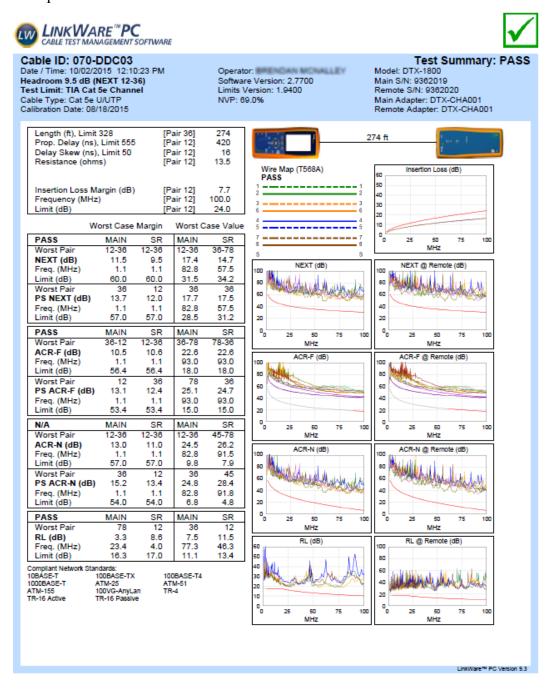
Use the attached embedded template file for the submittal:

Wiring Installation Qualification Form.docx

The above document is attached in the UofT FS_BAS_Standard.pdf file as the PDF attachment

3.21.2 FLUKE Reports Requirements

The LINKWARE Fluke Report must be provided as per the following template. Cable ID must correspond with the Cable ID record from the Installation Checklist.



3.21.3 EMRS BACnet Compliance Test Readiness Form – Vendor Specific Template for B-BC controllers (ETHERNET Interface only)

IMPORTANT NOTE: The content of all the screenshots must be easily read. Failure to provide properly captured and easy to read screenshot will result in a delay of the approval process.

HONEYWELL (HBS)

Device Name	Fluke Report Cable ID	Digital Picture(s) of the device TELNET session indicating the current system time and TCP IP settings:	Digital Picture(s) of the device TELNET session indicating the PORT CONFIGURATION INFORMATION	Digital Picture(s) of the device TELNET session indicating the CONTROLLER DEVICE INFORMATION	Date / Initials
EXAMPLE: 005_DDC01	005_DDC01	+ (C) Copyright by HONEYWELL Technology Solutions Lab Bangalore 2006-2015+	+ (C) Copyright by HONEYWELL Technology Solutions Lab Bangalore 2006-2015+	+ (C) Copyright by HONEYWELL Technology Solutions Lab Bangalore 2006-2015+	01-MAR- 2019, AB

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SIEMENS (SBT)

Device	Fluke	Digital Picture(s) of the device TELNET session indicating the TCP IP settings:						
Name	Report	21910011100010(3) 01 0110 00 110 1	Digital Field (6) of the defice 122 (21 beside matering the 101 II bettings.					
Name				Initials				
	Cable ID							
EXAMPLE:	08s			01-MAR-				
080_DDC03	0_DDC03	>Display, Modify, dhcpRelease, re	New, Quit? -	2019, AB				
		06/05/2019 WED Et	hernet Setup Report 17:59					
		Names						
		Node name	: 080DDC01					
		Site name	:					
		BLN name	: BACBLN					
		IP Settings						
		DNS Suffix						
		DHCP	: Disabled					
		IP Address Netmask	: 172. 19.128. 20					
			: 255.255.255.128					
		Gateway Address	: 172. 19.128. 1					
		DNS 1	: 0. 0. 0. 0					
		DNS 2	: 0. 0. 0. 0					
		DNS 3	: 0. 0. 0. 0					
		DNS 4	: 0. 0. 0. 0					
		Telnet Enabled	: Enabled					
		BACnet Device Settings						
		Device Instance Number Device Location Device Description	: 380001					
		Device Location	: PENTHOUSE					
		Device Description	:					
		Device Reserved Instance Base						
		COV Resubscribe Period (min)	: 30					
		COV Poll Rate (sec)	: 60					
		BACnet IP ALN Settings	: Enabled					
		BACnet IP Network Number	: 1					
		UDP Port	. 47003					
		Act as a Foreign device	: NO					
		BACnet MSTP ALN Settings						
		(Note When FLN is MS/TP, and MS						
		MS/TP ALN may also be used as	second MS/TP FLN)					
		FLN Settings	: Disabled					
		End of report						
		>Display, Modify, dhcpRelease, re	New, Quit? -					

Johnson Controls (JCI)

Device Name	Fluke Report Cable ID	Digital Picto TCP IP sett	e device Launcher sessi	on indicating the l	Local Server time and the		al Picture(s) FIGURATION 1			Launcher	session	indicating	the	PORT	Date / Initials
EXAMPLE: 070_DDC01	070_DDC01	In Edit I are 3-500 best I los gent Sent Sent Sent Sent Sent Sent Sent S	Lateful Edward modern 3 s cond 1 minute 5 Fisher a modern 3 Fisher administrator ************************************	OS_DOCEST OWNTHOMAL Remail	Last Login. The 600402019 09 22 44 EDIT for 100 000 100 100 000 10	Focus Edit Attri BAC C S N E F V V A L L F		Value 005_DDC e True 305401 Operation 1001 47808 Listof[0]	:401	ail Pager SNMP	Syslog Alarr	m Trend	005_DDC Operation	401 al Normal	01-MAR-2019, AB

Use the attached embedded template file for the submittal:

EMRS BACnet Compliance Test Readiness Form.docx

The above document is attached in the UofT FS_BAS_Standard.pdf file as the PDF attachment

3.21.4 Project Points List EMRS Submittal Form – Specific Template for B-BC controllers (ETHERNET Interface only)

Use the attached embedded template file for the submittal:

Project Points List EMRS Submittal Form.xlsx

The above document is attached in the UofT FS_BAS_Standard.pdf file as the PDF attachment

3.22 DIAGRAMS AND SCHEDULES

- Figure 1 Typical Dynamic Symbols for Alarming & Operator Override
- Figure 2 Sample of AHU system graphic
- Figure 3 Sample of Chilled Water system graphic
- Figure 4 Sample of Glycol Loop system graphic
- Figure 5 Sample of Heating Water loop system graphic
- Figure 6 U of T Cabling Specifications
- Figure 7 Point Naming Structure for Buildings and Systems

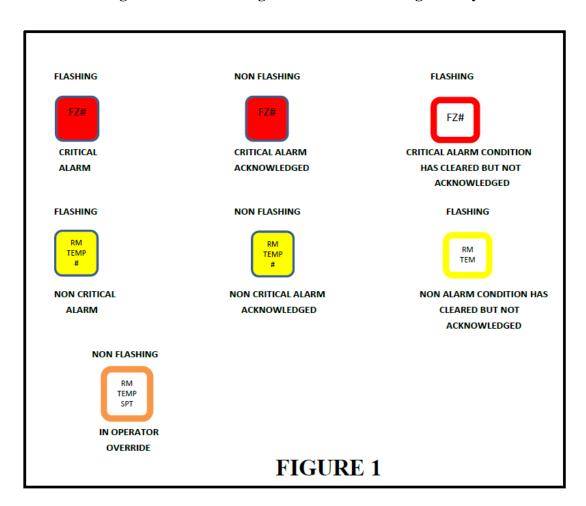


Figure 1 Typical Dynamic Symbols for Alarming & Operator Override

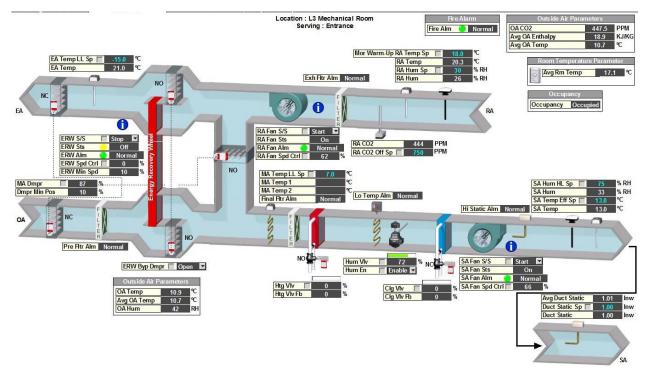


Figure 2 Sample of AHU system graphic

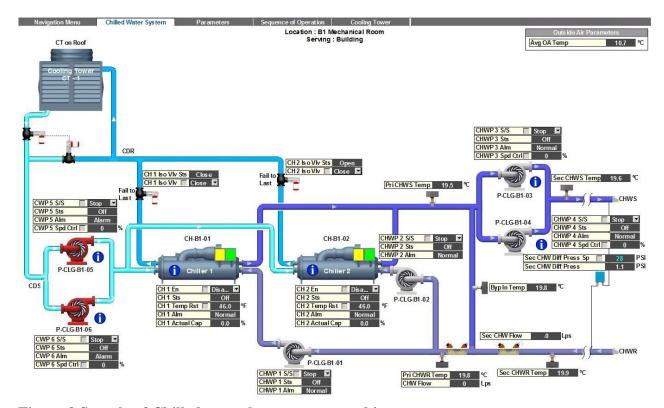


Figure 3 Sample of Chilled water loop system graphic

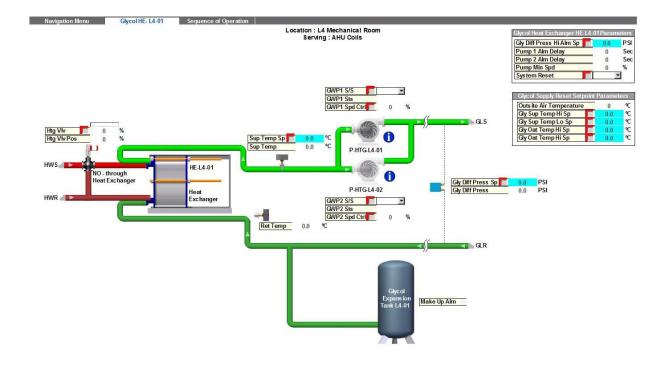


Figure 4 Sample of Glycol Heating loop system graphic

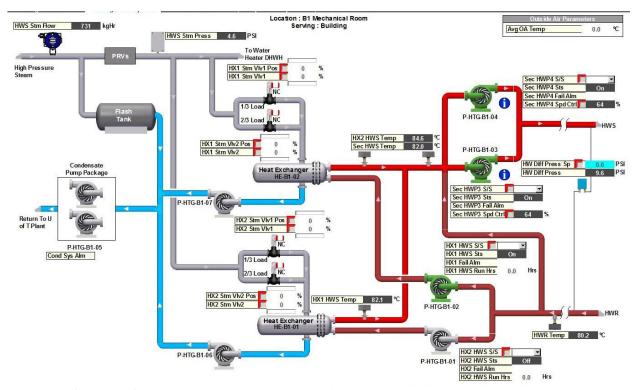


Figure 5 Sample of Heating Loop system graphic

U of T TYPICAL CONTROL WIRE & CABLE SCHEDULE

FIGURE 6

ITEM	WIRE USE	DISCRIPTION	WIRE SIZE	WIRE COLOUR
1	AC POWER WIRE	DISTRIBUTION (24/120 VAC)	12-14 AWG	BLACK
		DISTRIBUTION (NEUTRAL)	12-14 AWG	WHITE
	DC POWER WIRE	DISTRIBUTION (+24VDC)	14-18 AWG	RED
,		DISTRIBUTION (-24VDC)	14-18 AWG	BLACK
2		DISTRIBUTION (+12VDC)	14-18 AWG	RED
		DISTRIBUTION (-12VDC)	14-18 AWG	BLACK
3	AC CONTROL SIGNAL WIRE	CONTROL SIGNAL (24/120VAC)	18 AWG	ORANGE
4	DC CONTROL SIGNAL WIRE	SIGNAL (+24VDC)	18-20 AWG	RED
		SIGNAL (-24VDC)	18-20 AWG	BLACK
5	GROUNDING	INSTRUMENT ISOLATION	12-14 AWG	GREEN/YELLOW
		SAFETY EARTHING	10-12 AWG	GREEN
6	ALARM	POWER SUPPLY FAILURE	18 AWG	YELLOW
ITEM	CABLE USE	WIRE SIZE	CONDUCTOR	WIRE COLOUR
	POWER CABLE AC - DISTRIBUTION	12-14 AWG	1 (LINE)	BLACK
7			2 (NEUTRAL)	WHITE
			3 (GROUND)	GREEN
	POWER CABLE DC - DISTRIBUTION	14-18 AWG	1 (+24VDC)	RED
8			2 (-24VDC)	BLACK
9	CONTROL CABLE DC - DISTRIBUTION	18 AWG -	1 (+)	RED
			2 (-)	BLACK
	SIGNAL ANALOG CABLE	SHIELDED/TWISTED	1 (+)	RED
10		PAIRED 18-20 AWG	2 (-)	BLACK
	SIGNAL ANALOG MULTI CONDUCTOR CABLE	SHIELDED/TWISTED PAIRED 18-20 AWG	1 RED	2 BLACK
11			3 WHITE	4 BLACK
			5 GREEN	6 BLACK
			7 BLUE	8 BLACK
12	CAT6 CONTROL NETWORK CABLE	COMMUNICATION		BLUE
	SINGLE TRIAD RTD CABLE	18 AWG	1 (+)	RED
13			2 (-)	WHITE
			3 (C)	BLACK

NOTE: 1. ALL WIRES CSA TYPE REW-600V FLEXIBLE, MUTISTRAND, TINNED COPPER, 105 °C

NOTE: 2. ALL SHIELDED CABLES SHALL BE CONTINUOUSLY SHIELDED. SHIELDS SHALL BE GROUNDED IN THE CONTROL PANEL AT THE POWER SOURCE END ONLY AND FLOATED AT THE OTHER END

NOTE: 3. BAS CONTROL NETWORK COMMUNICATION CABLE SHALL NOT BE SPLICED

Figure 6 U of T Cable Specifications

Figure 7 U of T POINT NAMING CONVENTION

CAMPUS NAME: ST. GEORGE CAMPUS

BUILDING CODE & NAME LIST

BUILDING CODE		BUILDING NAME
001	-	University College
002	-	Hart House
003	-	Sig. Sam. Library
004	-	McMurrich
005	-	Medical Science
006	-	Robarts Library
006A	-	Clude T. Bissel Lib
006B	-	Fisher Rare Book Lib
007	-	Mining Inst.
008	-	Wallberg
008A	-	D.L. Pratt
009	-	Sanford Fleming
010	-	Simcoe Hall
010A	-	Convocation Hall
011	-	Tanz Institute.
012	-	Munk Centre
013	-	Whitney Hall
014	-	Faculty of Education - 371 Bloor St. west
016	-	Banting Institute.
018	-	Central Steam Plant
019	-	Development & University Relations
020	-	Rosebrugh Building
021	-	Engineering Annex
022	-	Mechanical Engineering
023	-	University College Union
024	-	Haultain
025	-	Fitzgerald
026	-	Cumberland House
027	-	Physical Geography
028	-	Architecture
029	-	Sir D. Wilson Residence
030	-	Varsity Stadium

030A	-	Varsity Arena
032	-	Wetmore Hall (New College I)
032A	-	Wilson Hall (New College II)
033	-	Sidney Smith Hall
034	-	Massey College
036	-	Astronomy
037	-	David Dunlop Observatory
038	-	Woodsworth College
039	-	Transitional Year Program
040	-	Flavelle House
041	-	Varsity Pavilion
042	-	Goldring
043	-	School of Grad. Studies
046	-	44 St. George
047	-	Canadiana Gallery
049	-	Aerospace Building
050	-	Falconer Hall
051	-	Edward Johnson
052	-	Best Institute
053	-	Institute Of Child Study
054	-	Daniels Faculty of Arch. and Landscape
055	-	President's House
056	-	Graduate Student Res. (GSU)
057	-	Bancroft Building
061	-	South Borden Building
061A	-	North Borden Building
062	-	Earth Science Center
064	-	Graduate House
065	-	Dentistry Building
067	-	215 Huron Street
068	-	Clara Benson Institute
068A	-	Warren Stevens Building
070	-	Galbraith
071	-	Obstetrics & Gynaecology
072	-	Ramsay Wright Laboratories
073	-	Lash Miller Chemical Laboratories
075	-	Faculty Club
077	-	Sussex Court
078	-	McLennan Laboratories
078A	-	Linac Laboratories
079	-	Faculty of Pharmacy
080	-	Bahen Centre for Information Tech

082	-	Gage Institute
083	-	256 McCaul Street
084	-	91 St. George (CIUT Radio)
085	-	245 College Street
088	-	Dept. and Centre of Religion
089	-	Admission Office
090	-	Centre for bioethics
091	-	Studio Theatre
093	-	Electrometallurgy Lab
097	-	Centre for Medieval Study
097A	-	Culture and Technology
98	-	90 Wellesley Street
100	-	Animal Laboratories
101	-	Morrison Hall (UC Residence)
102	-	Soldiers' Tower
103	-	School of Continuous Study
104	-	Economics Department
105	-	Field's Institute
110	-	Centre for Industrial Relations
111	-	Social Work
115	-	Classic Department
117	-	W. B. Mac Field
120	-	Steward Observatory (SAC)
122	_	North West Chiller Plant
123	-	OISE
125	_	Internal Audit
127	-	172 St George
128	_	Jackman Humanities Building
129	_	Early Learning Centre
130	_	Woodsworth Residence
131	-	New College Res.(New Coll. III)
132	_	Innis College
133	_	Innis Residence
134	_	Rotman School of Management
135	_	St George Parking Garage
136	_	705 Spadina Avenue
138	_	Caretaking
139	_	Co-op Daycare
141	_	Margaret Flet. Daycare
142	_	713 Spadina Avenue
143	_	Koffler Student Centre
145	_	Koffler Pharmacy Management
-		January Management

146	-	40 Sussex Avenue
148	-	368 Huron Street
149	-	UTL Archives
150	-	58 Spadina Road
151	-	655 Spadina Avenue
152	-	500 University Avenue
153	-	56 Spadina Road
154	-	Health Sciences Building
155	-	Exam Centre
156	-	BOE 263 McCaul
158	-	Chestnut Residence
160	-	CCBR
161	-	L.D. Pharmacy
171	-	455 Spadina Rd
172	-	MacDonald-Mowat House
174	-	203 College Street
179	-	229 College Street
186	-	620 University Avenue
189	-	720 Spadina Avenue
192	-	Stuart Building
790	-	30 Charles Street
791	-	35 Charles Street

VICTORIA UNIVERSITY

501	-	Victoria College
502	-	Emmanuel College
503	-	Birge-Carnegie Library
504	-	Burwash Hall
505	-	Victoria Men's Resdence
506	-	Annesley Hall
507	-	Wymilwood
508	-	Margaret Addison Hall
509	-	Isabel Bader Theatre
513	-	Stephenson House
514	-	E.J. Pratt Library
515	-	Northrop Frye Hall
518	-	Rowell Jackman Hall
524	-	110 Charles St. West
528	-	Lillian Massey
575	-	Knox College

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TRINITY COLLEGE

600 - Trinity College

601 - Chapel

602 - Gerald Larkin Building
603 - George Ignatieff Theatre
608 - St. Hilda's College
675 - Wycliffe College
970 - Clarke Institute

SYSTEM NAME LIST

<u>ABBREVIATION</u> <u>DESCRIPTION</u>

AHU#; - AIR HANDLING UNIT

ALN#; - AUTOMATION LEVEL NETWORK
AMMICEPLT#; - AMMONIA ICE PLANT SYSTEM
ATS#; - AUTO TRANSFER SWITCH SYSTEM

BIOHLAB#; - BIOHAZARD LABS SYSTEM

BLR#; - BOILER SYSTEM

BLN#; - BUILDING LEVEL NETWORK
CTRAIR#; - CONTROL AIR SYSTEMS

CAV#; - CONTSTANT AIR VOLUME TERMINAL BOX CONTROL SYSTEMS

CHLR#; - CHILLER SYSTEM

CHLW#; - CHILLED WATER SYSTEM

CLDRM#; - COLD ROOM OR LAB COOLING SYSTEM

CLGPLT#; - COOLING PLANT SYSTEM

CLGTWR#; - COOLING TOWER SYSTEM

CGW#; - CAGE WASHING SYSTEMS

COMPARE - COMPRESSED AIR SYSTEM

CDNW#; - CONDENSER WATER SYSTEM

CNDP#; - CONDENSATE PUMP SYSTEMS

COR#; - CORRIDOR/HALLWAY CONTROL POINTS

DCW#; - DOMESTIC COLD WATER SYSTEM
DHW#; - DOMESTIC HOT WATER SYSTEM

DX#; - DIRECT EXPANSION SYSTEMS (The # is stage #)

EMGEN#; - EMERGENCY GENERATOR SYSTEM

FA#; - FIRE ALARM SYSTEM

FAN#: - MISCELLANEOUS & GENERAL PURPOSE FANS

FCU#; - FAN COIL UNITS

FREECLG#; - FREE COOLING SYSTEM FLN#; - FLOOR LEVEL NETWORK

FUELOIL#; - FUEL OIL SYSTEM

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FUMH#; - FUME HOOD SYSTEM HPMP#; - HEAT PUMP SYSTEM

HRU#; - HEAT RECOVERY UNIT/ENERGY HEAT WHEEL

HX#; - HEAT EXCHANGER SYSTEM

HW#; - HOT WATER SYSTEM

HWHX#; - HOT WATER HEAT EXCHANGER SYSTEM

HTHWHX#; - HIGH TEMP. HOT WATER HEAT EXCHANGER SYSTEM
HTR#; - HEATER (E.G. UNIT, CABIENT, DUCT, GAS FIRED HEATERS)

IUCB - INDUCTION UNIT CHILLED BEAM SYSTEM
 KW#; - ELECTRIC & ELECTRIC METERING SYSTEMS

LAB#; - LABORATORY AREA/ZONE/LEVEL

LABAIR#; - LABORATORY COMPRESSED AIR SYSTEMS

LABGAS#; - LABORATORY GAS SYSTEMS(Use gas type in device name)

LABRC#; - LABORATORY ROOM CONTROLLER

LABVAC#; - LABORATORY VACUUM COMPRESSED AIR SYSTEM

OR#; - SURGICAL OPERATING ROOMS
RO#; - REVERSE OSMOSIS SYSTEMS

SAS#; - SUPPLY AIR SYSTEMS

SUMP#; - SUMP PUMP
TNK#; - TANK SYSTEMS

VACAIR#; - VACUUM COMPRESSED AIR SYSTEM

VAV#; - VARIABLE AIR VOLUME TERMINAL BOX SYSTEM

WSHR#; - STERILIZED (WASHER)

WUM#; - WARM-UP MODE ZN#; - ZONE SYSTEMS

DEVICE NAME LIST:

<u>ABBREVIATION</u> <u>DESCRIPTION</u>

AFM#; - AIR FLOW METERING DEVICES
AFS#; - AIR FLOW SWITCH DEVICES

AIRCOMP#; - AIR COMPRESSOR AIRX#; - AIR CHANGES

ALM#; - ALARM
AMP#; - AMPERAGE
ANALZ#; - ANALYSOR
AUTO#; - AUTOMATIC
AVG#; - AVERAGE
BAT#; - BATTERY

BELL#; - HORNS AND BELLS

BLDG#; - BUILDING BRG#; - BEARINGS

BYP#; - BYPASS DEVICES

CFM#; - CUBIC FEET PER MINUTE

CD#; - COLDDECK
CL#; - CHLORINE
CLG#; - COOLING

CLGDNM#; COOL-DOWN MODE

CLN#; - CLEANING DEVICES (i.e., cage washer)

CLNRM#; - CLEAN ROOM

CO#; - CARBON MONOXIDE

COMP#; - COMPRESSOR
COND#; - CONDUCTIVITY
CO2#; - CARBON DIOXIDE

CDNW#; - CONDENSER WATER DEVICES

CTRL#; - CONTROL

CYP#; - CYPRUS T,STAT DEVICE

DAMP#; - DAMPER DAY#; - DAY

DEC#; - DECREMENT
DEWPT#; - DEWPOINT

DEHUM#; - DEHUMIDIFIER DEVICES

DISA#; - DISABLE DLY#; - DELAY

DP#; - DIFFERENTIAL PRESSURE DEVICES

DWDUCT#; - DOWN DUCT DEVICES EAF#; - EXHAUST AIR FAN

EAST; - EAST

ECON#; - ECONOMIZER DEVICES

ENT#; - ENTERING ENTH#; - ENTHALPY

EP#; - ELECTRIC/PNEUMATIC COIL

EN#; - ENABLE/DISABLE Points (NOT Based on a Schedule)

EMER#; - EMERGENCY DEVICES

ESW#; - END SWITCH

EH#; - ELECTRIC HEAT DEVICES

EXHCFM#; - EXHAUST CFM
EXH#; - EXHAUST
EXHLAB#; - LAB EXHAUST

EXHWASHRM#; - WASH ROOM EXHAUST EXHGENRL#; - GENERAL EXHAUST

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EXP#; - EXPANSION (OBJECTS)
FBDAMP#; FACE & BYPASS DAMPER

FAN#; - FANS FAULT#; - FAULT

FAST#; - FAST SPEED FDBK#; - FEEDBACK FB#; - FACE BYPASS

FLO#; - FLOW

FLR#; - FLOOR SPECIFICATION (Where # is B3, B2, B1, 1...10, 11..., PH)

FLTR#; - FILTER

FT#; - FLOW TRANSMITTER

FZ#; - FREEZE STAT PROTECTION
G#; - GLOBAL OR VIRTUAL POINT

GEN#; - GENERATOR

GPM#; - GALLONS PER MINUTE

GILFLOM#; - GILFLO METER
H2#; - HYDROGEN
HD#; - HOTDECK
HE#; - HELIUM

HEPFLTR - HEPA FILTER

HI#; - HIGH
HR#; - HOURLY
HS#; - HIGH SPEED

HTHW#; - HIGH TEMPERATURE HOT WATER

HTG#; - HEATING HTRC#; - HEAT TRACE

HT#; - HIGH TEMPERATURE

HL#; - HIGH LIMIT

HLS#; - HIGH LIMIT SUPPLY
HLR#; - HIGH LIMIT RETURN
HOA#; - HAND-OFF-AUTO

HOTRM#; - HOT ROOM SYSTEM POINTS

HOUR#; - TIME HOURS

HP#; - HIGH PRESSURE DEVICES

HUM#; - HUMIDITY DEVICES
HUMSPT#; - HUMIDITY SETPOINT

INC#; - INCREMENT

ISO#; - ISOLATION DEVICES

LCN#; - LOCATION (EG CONTROL PANEL RESIDENCE)

LEADLAG#; - LEAD/LAG TOGGLE

LIT#; - LIGHTS

LAB#; - LABORATORY (WHERE # IS THE ROOM NUMBER)

LITON#; - LIGHT ON TIME LITOFF#; - LIGHT OFF TIME

LITPRF#; - LIGHT PROOF (Photo Cell)

LL#; - LOW LIMIT

LOAD#; - LOAD (Used for Chillers, Electrical)

LOC#; - LOCAL CONTROL POINT

LOW#; - LOW

LS#; - LOW SPEED LPO#; - LOOP OUTPUT

LT#; - LOW TEMPERATURE

LVG#; - LEAVING

LVL#; - LEVEL INDICATION

MAN#; - MANUAL
MAKUP#; - MAKE-UP
MD#; - MODE

MECHRM#; - MECHANICAL EQUIPMENT ROOM LOCATION

MEDGAS#; - MEDICAL GAS SYSTEMS (Use gas type in device name)

METER#; - METERS
MIN#; - MINIMUM

MED#; - MEDIUM OR MEDIAN

M#; - MODE
NORTH; - NORTH
MON#; - MONTHLY

MTHWHX#; - MEDIUM TEMP. HOT WATER HEAT EXCHANGER SYSTEM

MXT#; - MIXED AIR DEVICES

N2#; - NITROGEN O2#; - OXYGEN

OA#; - OUTSIDE AIR DEVICES

OCC#; - OCCUPANCY (Based on a Schedule)

OCC-OVRD#; - OCCUPANCY OVERRIDE

OFF#; - OFF
OFFST#; - OFFSET
ON#; - ON

OPER#; - OPERATOR

OVLD#; - OVERLOAD DEVICES
OVRD#; - OVERIDE DEVICES

PARKGR#; - PARKING GARAGE SYSTEM
PB#; - PROPORTIONAL BAND

PCT#; - PERCENT

PF#; - PREFILTER DEVICES
PH#; - ACID/BASE LEVEL
PHT#; - PREHEAT DEVICES

PLTPRTY#; - PLANT PRIORITY

PMP#; - PUMP DEVICES OR NUMBER

POS#; - POSITION

PPM#; - PARTS PER MILLION

PRC#: - PRESSURIZD ROOM CONTROLLER

PRF#; - PROOF
PRI#; - PRIMARY

PRS#; - PRESSURE SWITCH

PRV#; - PRESSURE REDUCING VALVE

PSI#; - PRESSURE GAUGE
PSPT#; - PRESSURE SET POINT
PT#; - PRESSURE TRANSMITTER

PMP#; - PUMP PWR#; - POWER

PWRFAIL#; - ON POWER RETURN POWER FAIL POINT FOR PANELS

R#; - RETURN DEVICES
RA#; - RETURN AIR DEVICES

RAREBKS#; - RARE BOOKS

RAF#; - RETURN AIR FAN

REFIGA#; - REFRIGERANT ALARM DEVICES

RST#; - RESET (COMMAND ONLY)

RHT#; - REHEAT DEVICES
RM#; - ROOM NUMBER

RMTEMP#; - ROOM TEMPERATURE

RMSPT#; - ROOM TEMPERATURE SETPOINT

RMHUM#; - ROOM HUMIDITY

RPC#; - ROOM PRESSURIZATION CONTROLLER

RPM#; - REVOLUTIONS PER MINUTE RSR#; - DUCT/PIPE RISER OBJECTS

SA#; - SUPPLY AIR DEVICE SAF#; - SUPPLY AIR FAN

SCHED#; - SCHEDULE SEC#; - SECONDS SECD#; - SECONDARY

SPT#; - SET POINT (Used as a suffix to any other device name)

SP#; - STATIC PRESSURE

SIG#; - SIGNAL STS#; - STATUS

S#; - SUPPLY DEVICES SW#; - SUMMER/WINTER

SMK#; - SMOKE CONTROL DEVICES

SOUTH; - SOUTH

SS#; - START/STOP

START#; - START (COMMAND ONLY)
STOP#; - STOP (COMMAND ONLY)

STS#; - STATUS

STBY#; - STANDBY DEVICES STM#; - STEAM DEVICES STMFL#; - STEAM FLOW

STMGEN#; - CLEAN STEAM SYSTEMS

STMHX#; - STEAM HEAT EXCHANGER SYSTEM
SURGYVACS#; - SURGERY VACUUM AIR SYSTEM

SWIMPL#; - SWIMMIMING POOL

TEC#; - TERMINAL EQUIPMENT CONTROLLER

TIMEDLY#; - TIME DELAY
TEMP#; - TEMPERATURE

TIME#; - TIME CONTROL UNITS

TOT#; - TOTALIZED VALUE OR TOTAL
TT#; - TEMPERATURE TRANSMITTTER
ULTRSFLOM#; - ULTRA SONIC FLOW METER

UVLIT#; - ULTRAVIOLET LIGHT

VANDAMP - VANE DAMPER

VEN#; - VENTURI

VP#; - VELOCITY PRESSURE

VFD#; - VARIBLE FREQUENCY DRIVE OUTPUT SIGNAL

VTXFLOM#; - VORTEX FLOW METER

VLV#; - VALVE WEST; - WEST

WD#; - WATER DETECTOR

#; - IDENTIFICATION NUMBERS

1 3			n the Section 'PART 3 EXECUTION' ign Specification documentation.
□ NO , the requiren		een incorpo	orated in the Design Specification. rated in the Design Specification. r the project the DS.
	nation, if NO or N/A options and		
1 3	Itant to provide the cross-regy Systems Design Standard		etween the sections in the Building
Building Automa	ation and Energy Systems		Design Specification
Design Standard Ex. 2.3		22.13	
		1	
CHECKLIST 13			
Date:	Consulting Engineer:		Signature:

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3.23 TERMINAL EQUIPMENT CONTROLLER (TEC) SUBMITTAL PACKAGE

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below.

3.23.1 TEC Bacnet Point Matrix

In order to complete the EMRS Bacnet Compliance Test, the BAS vendor shall submit the Microsoft Excel (XLSX) digital version of the Bacnet Point Matrix for every Bacnet MSTP Terminal Equipment Controller (TEC) that is connected and integrated to the EMRS Bacnet communication layer (IP, MSTP). TEC includes any ASC or AAC controller used in the project.

The mandatory fields are:

- 1 Name of the ASC/AAC controller (Terminal Equipment Controller, TEC)
- 2 List of all the Bacnet objects related to the application
- 3 Bacnet Object Description
- 4 Bacnet Units
- 5 Bacnet Object Type
- 6 Bacnet Object Instance Number
- 7 ASC/AAC Application Notes

Below is the screenshot of the digital file (Excel XLSX) that is expected to be submitted:

072 CHLR1 BTU1 [372051]	5		fMRI CH BTU Metr																				-	_
ons_cimici_bioi [5,2001]	-	AV_1	Total Energy	LAI	Y 1.5.	1 1	Value						+						+	+-	+-	Analog Value	1	AV_I
	_	AI_1	Energy Rate	LAI	Y 1.5.		Value						+				_			+-	+-	Analog Input	<u>-</u>	AI
	_	AV_2	Total Flow	LAI	Y 1.5.	_	Value			_			+							+-	+-	Analog Value	-	AV
	+	AI_2	Flow Rate	LAI	N 1.5.		Value						+						+	+-	+	Analog Input	1	AI
	_	AI_3	Supply Temperature	LAI	N 1.5.		Value			_			+							+-	+-	Analog Input	-	AI
	+	AI_4	Return Temperature	LAI	N 1.5.		Value						+						+	+	+	Analog Input	4	AI
	+	AI_5	Delta T	LAI	Y 1.5.	_	Value		\vdash	_			+							+-	+	Analog Input	-5	AI
	_	BV_1	Energy Total Reset	LDO	Y 1.5.		On/Off						1						+	+-	+	Binary Value	1	BV
		BV_2	Flow Total Reset	LDO	Y 1.5.		On/Off						1						 	+	+	Binary Value	2	BV
		AV_3	Auxilliary Input Total	LDI	N 1.5.		Pulse						1						 	+-	+-	Analog Value	3	AV
		BV_3	Auxilliary Input Reset	LDO	Y 1.5.		On/Off						1						+	+	+	Binary Value	3	BV
			,		-														<u> </u>	+	 		+	+-
072_VAV1.1_TEC1 [372061] 6	6		Mock Scanner 177																<u> </u>	+	†	1	+	+
		ROOM TEMP	Room Temperature	LAI	N 1.6.	4 1	Value		8	45	DegC	0.5					Y	25	18	60	1	Analog Input	4	ΑI
		HEAT.COOL	Heat or Cool Mode	LDO	Y 1.6.	5 0	On/Off						N	COOL	HEAT	N	N			1		Binary Value	5	BV
		NGT OVRD	Night Override Mode	LDO	Y 1.6.	21 0	On/Off						N	DAY	NIGHT	N	N					Binary Value	21	BV
		DAY.NGT	Schedule Point	LDO	Y 1.6.	29	On/Off						N	DAY	NIGHT	N	N					Binary Value	29	BV
		AIR VOLUME	Measured Air Flow	LAO	Y 1.6.	35 \	Value		0	10000	LPS	10					N					Analog Value	35	AV
		DMPR COMD	Damper Command	LAO	Y 1.6.	48 T	Value		0	100	PCT	1					N					Analog Value	48	AV
		DMPR POS	Damper Position	LAO	Y 1.6.	49 T	Value		0	100	PCT	1					N					Analog Value	49	AV
		VLV1 COMD	Reheat Command	LAO	Y 1.6.	52 V	Value		0	100	PCT	1					N					Analog Value	52	AV
		VLV1 POS	Reheat Position	LAO	Y 1.6.	53 1	Value		0	100	PCT	1					N					Analog Value	53	AV
		FLOW	Flow Percentage	LAO	Y 1.6.	75 \	Value		0	1000	PCT	1					N					Analog Value	75	AV
		CTL FLOW MIN	Minimum Set Point	LAO	Y 1.6.	76 \	Value		0	10000	LPS	1					N					Analog Value	76	AV
		CTL FLOW MAX	Maximum Set Point	LAO	Y 1.6.	77 1	Value		0	10000	LPS	1					N			T		Analog Value	77	ΑV
		CTL TEMP	Current Temp Value	LAO	Y 1.6.	78 \	Value		8	45	DegC	0.5					N					Analog Value	78	AV
		CTL STPT	Temperature Set Point	LAO	Y 1.6.	92 \	Value		8	45	DegC	0.5					N					Analog Value	92	AV
		FLOW STPT	Airflow Set Point (%)	LAO	Y 1.6.	93 \	Value		0	250	PCT	1					N					Analog Value	93	AV
		RM RH	Room Humidity	LAI	N 1.6.	126 1	Value		0	100	%RH	1			1	1	N		†	1	1	Analog Value	126	AV

Figure 8 : BACnet Object Point Matrix

3.23.2 TEC Field Layer Network Schedule (MSTP ASC/AAC TEC Controllers)

In order to complete the EMRS Bacnet Compliance test, the BAS vendor shall submit the Microsoft Excel (XLSX) digital version of the Bacnet Field Layer Network Schedule with the list of all the MSTP controllers and their association with the routed networks and B-BC controllers.

The mandatory fields are:

- 1 Name of the ASC/AAC controller (Terminal Equipment Controller, TEC)
- 2 Bacnet Controller Instance number
- 3 Description of the system/location served
- 4 MSTP Routed network ID
- 5 ASC/AAC Application ID or Type

Below is the screenshot of the digital file (Excel XLSX) that is expected to be submitted:

MS/TP Field Le	evel Network Sche	dule													F	roject:	U of T - R	amsay W	right - fMF	RI Suite								
ield Panel Informa											Terminal Box Information:																	
ystem Name:	072_DDC_01								Panel MS	S/TP Address:	: 0				Box Mani	ıfacturer:	E.H.	Price										
anel Location:	Level B2, Mechanical F	Room							FLN Bau	d Rate:	38400	bps			Rotation A	Ingle:	90	Degrees	5									
ACnet Instance No.:	372001								BACnet I	Network No.:	372				Initial Flov	v Coefficie	nt: 0.78											
anel Type:	Modular																											
BACnet Object Name:	072DDC01								Note: FLN2	and FLN3 are not	available for BACnet MS/T	P Connection	1.															
System Name	Description	Terminal Box ID	Mechanic No.	al Drawing	Box Unit Size (mm)	Duct Inlet Area (M2)	1 -	BACnet Master or SI Instance		Served By	Type of Control	TEC Appl. No. (02)		Clg Flow Max (L/s) (32)	Htg Flow Min (L/s) (33)	Htg Flow Max (L/s) (34)	Motor Setup (58)	MTR 1 Timing (51)	MTR 2 Timing (55)	MTR 3 Timing (39)	Custom PPCL.	Design Flow (L/s)	Actual Press Drop (kPa)	Valve Cv	Valve Body		Valve Size (mm)	Control Va
	Do Not Use - Reserved for F	ield Panel MS	TP Node	Address					0																			
072_CHLR1_PMP1	CH Evap Pump 1	P-CH-1	M802		-	-	М	372011	1	-	VFD (Pump)	11201	-	-	-	-	-	-	-			-	-	-	-	-	-	-
072_CHLR1_PMP2	CH Evap Pump 2	P-CH-2	M802		-	-	М	372021	2	-	VFD (Pump)	11201	-	-	-	-	-	-	-			-	-	-	-	-	-	
072_CHLR1_PMP3	CH Cond Pump 3	P-CW-3	M802		-	-	М	372031	3	-	VFD (Pump)	11201	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-
072_CHLR1_PMP4	CH Cond Pump 4	P-CW-4	M802		-	-	М	372041	4	-	VFD (Pump)	11201	-	-	-	-	-	-	-			-	-	-	-	-	-	-
072_CHLR1_BTU1	fMRI CH BTU Metr	BTU-1	M802		-	-	М	372051	5	-	BTU Meter	11202	-	-	-	-	-	-	-			-	-	-	-	-	-	-
072_VAV1.1_TEC1	Mock Scanner 177	VAV-1.1	M502	F.5/8.3	250	0.050	М	372061	6	Exist AHU	VAV w/Reheat	6623	88	293	88	88	13	90	130	-		0.13	29.27	1.00	3W	D	15	260-0206
072_VAV1.2_TEC2	Waiting Area 172	VAV-1.2	M502	E.5/9.5	250	0.050	М	372071	7	Exist AHU	VAV w/Reheat	6623	35	115	35	35	13	90	130	-		0.13	29.27	1.00	3W	D	15	260-0206
					-	-																-	-	-			-	
					-	-																-	-	-			-	
072_FCU2.1_TEC3	Server Room 178	FC-2.1	M502	G/10.4	-	-	S	372081	128	-	Fan Coil, Cool Only	6645	-	-	-	-	1	130	-		N	0.44	21.12	4.00	2WNC	-	15	260-020
072_FCU2.2_TEC4	Equip Room 179	FC-2.2	M502	F.6/10.9	-	-	S	372091	129	-	Fan Coil, Cooling	6645	-	-	-	-	13	130	130	-	N	0.10	17.65	1.00	2WNC	-	15	260-020
											& Heating										\perp	0.11	19.93	1.00	3W	D	15	260-020
072_FCU2.3_TEC5	Exam Room 180	FC-2.3	M502	D.5/13.5	-	-	S	372101	130	-	Heat Pump	6674	-	-	-	-	-	130		-	Υ	0.44	21.12		2WNC	-	15	260-020
072_FCU2.4_TEC6	Control Rm 181	FC-2.4	M502	D.4/13.4	-	-	S	372111	131	-	Fan Coil, Cooling	6645	-	-	-	-	13	130	130	-	N	0.10	17.65	1.00	2WNC	-	15	260-020
											& Heating											0.11	19.93	1.00	3W	D	15	260-020

Figure 9 : AAC/ASC Field Layer Network Schedule

1 3	tant confirming that all the re n incorporated in the project's	1	s in the Sections 3.23 and 3.24 of this ecification documentation.
□ NO , the requiren		een incorpo	porated in the Design Specification. rated in the Design Specification. r the project the DS.
	nation, if NO or N/A options a		
1 0	lltant to provide the cross-ratergy Systems Design Standard		etween the sections in the Building roject Design Specification:
	ation and Energy Systems		Design Specification
Ex. 2.3		22.13	
		, -	
		T	
CHECKLIST 14			
Date:	Consulting Engineer:		Signature:

PART 4 – ACKNOWLEDGMENT OF READING AND UNDERSTANDING OF THIS DOCUMENT

4.1 GENERAL INFO

4.1.1 The purpose of this section is to ensure that internal and external stakeholders have read and understand on how to use this document.

4.2 PROCESS DETAILS

- 4.2.1 This process shall be documented via a sign off document forwarded to the Administration Assistant of the Director of Utilities and Building Operations for filing at the end of the project by the Project Manager.
- 4.2.2 Updated training via the reading of this procedure will be required annually by the Facilities and Services and the University Planning Design and Construction.
- 4.2.3 Individual projects will require acknowledgement of this requirement as part of the bid process:
- 4.2.4 The Project Manager shall provide sign off sheet at the onset of the project that will be signed off by internal and external stakeholders as they become involved at various stages of the project.

4.2.5 Parties involved:

- a. The functional areas responsible for the Management, Operation, Maintenance, Planning, Design and Construction of the building system inclusive but not restricted to personnel in Facilities and Services and University Planning Design and Construction.
- b. The Contracted service providers (consultants, contractors, etc.) that impact change into any aspect of the Building System, documentation of such training will be included in the completed Commissioning document as described in the Commissioning Documentation Section of this procedure.

Building Automation and Energy Systems Design Standard

Acknowledgement of reading and understanding of Building Automation and Energy Systems Design Standard

Project ID:
Project Name:
UofT Project Manager

Name	Title	Date	Signature	
Tuille	11110	Date	Digitature	