

SECTION 15952/BUILDING AUTOMATION SYSTEM1 GENERAL

- 1.1 A complete microprocessor controlled compatible building automation and control systems tested and ready for operation.
- 1.2 Contractor shall furnish and install a direct digital control and building automation system (BAS). The BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform control sequences and functions specified. The BAS for this project will generally consist of monitoring and control of systems listed below. Reference also controls drawings, sequences of operation, and point lists.
- 1.3 Automation and/or monitoring for the various systems such as but not limited to:
 - 1.3.1 Air Handlers
 - 1.3.2 Air Handlers
 - 1.3.3 Variable Frequency Drives
 - 1.3.4 Zone Terminal Units
 - 1.3.5 Fan Coil Units
 - 1.3.6 Pumps
 - 1.3.7 Heat Exchangers
 - 1.3.8 UPS Equipment
 - 1.3.9 Energy Recovery Equipment
 - 1.3.10 Generators
 - 1.3.11 Boilers
 - 1.3.12 Energy Meters
 - 1.3.13 Stand Alone Building Chiller
 - 1.3.14 Campus Chiller
 - 1.3.15 Occupancy Sensors
- 1.4 In addition to monitored and controlled equipment, this section also includes:
 - 1.4.1 Communication and Low voltage cable and pathway requirements.
 - 1.4.2 Power requirements.
 - 1.4.3 Instrumentation – Product specifications and Installation requirements.
 - 1.4.4 Other miscellaneous items required but not specified for a complete operational system.
- 1.5 Products supplied but not typically installed under this section:
 - 1.5.1 Control Valves
 - 1.5.2 Control Dampers
 - 1.5.3 Instrument wells
 - 1.5.4 Flow Meters
 - 1.5.5 Energy Meters
- 1.6 Related Sections:

- 1.6.1 Section 15005 – Motors
- 1.6.2 Section 15520 – Valves
- 1.6.3 Section 15550 - Vibration Isolation
- 1.6.4 Section 15910 - Control Sequences
- 1.6.5 Section 159xx – Testing, Adjusting and Balancing
- 1.6.6 Section 159xx – Commissioning
- 1.6.7 Section 16130 - Raceway and Fittings
- 1.6.8 Section 16120 - Conductors and Cables
- 1.7 Related Sections:
 - 1.7.1 FCC Part 15, Subpart J Class A Computing Devices
 - 1.7.2 UL 864/UUKL Smoke Control Listing (Ninth Edition)
 - 1.7.3 UL 873 Temperature-Indicating and Regulating Equipment
 - 1.7.4 UL 916 Energy Management Systems
 - 1.7.5 NEMA Comply with NEMA Standards pertaining to components and devices for electrical controls
 - 1.7.6 NFPA 70 National Electrical Code
- 1.8 Definitions: The following abbreviations, acronyms, and definitions apply to and are used within this Guide Specification:
 - 1.8.1 Actuator Control device to provide motion of valve or damper in response to control signal.
 - 1.8.2 AHU Air Handling Unit
 - 1.8.3 AI Analog Input
 - 1.8.4 AO Analog Output
 - 1.8.5 Analog A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values
 - 1.8.6 Auto-Tune Software routine used to adjust tuning parameters based on historical or real-time data
 - 1.8.7 ASC Application Specific Controller
 - 1.8.8 BAS Building Automation System
 - 1.8.9 BLC Building Level Controller – Supervisory control panel and the primary means of communication outside the building. May also act as a global controller, implementing building wide global strategies and energy management routines.

1.8.10	CxA	Commissioning Authority
1.8.11	Control Sequence	A BAS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
1.8.12	DDC	Direct Digital Control
1.8.13	DDCP	Direct Digital Control Panel
1.8.14	Discrete	A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level each separated by a defined deadband. Digital Inputs and Digital Outputs are examples
1.8.15	DI	Discrete Input
1.8.16	DO	Discrete Output
1.8.17	EEPROM	Electronically Erasable Programmable Read Only Memory
1.8.18	EMI	Electromagnetic Interference
1.8.19	EMT	Electrical Metallic Tubing
1.8.20	E-P	Electric to Pneumatic
1.8.21	Fat Client	A network computer with a hard disk drive.
1.8.22	FC	Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
1.8.23	FO	Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
1.8.24	Furnish	Supply but not install.
1.8.25	GUI	Graphical User Interface
1.8.26	I/O	Input/Output (typically referring to points monitored by a system).
1.8.27	I/P	Current to pneumatic transducer
1.8.28	Instrument	Device used for sensing input parameters or used for actuation
1.8.29	IP	Internet Protocol
1.8.30	HOA	Hand Off Auto
1.8.31	Install	To mount, but not furnish.
1.8.32	LAN	Local Area Network
1.8.33	IT	Information Technology
1.8.34	LOT	Local Operator Terminal
1.8.35	Modulating	Movement of a control device through an entire range of values proportional to an infinitely variable input value.
1.8.36	Motorized	Control device with actuator.
1.8.37	NC	Normally Closed position of switch contacts after control signal is removed.
1.8.38	NO	Normally Open position of switch contacts after control signal is removed.
1.8.39	Node	DDCP, user workstation, or other control device connected to communications network.
1.8.40	Operator	Same as actuator
1.8.41	Owner	Florida State University (FSU Project Manager)
1.8.42	OWS	Operator’s Work Station (Personal Computer with Intranet / Internet capability)
1.8.43	PC	IBM-compatible Personal Computer from a recognized major manufacturer. PC “clones” assembled by a third-party subcontractor are not acceptable
1.8.44	PDA	Personal Digital Assistant

1.8.45	Peer-to-Peer	Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
1.8.46	P1/P2	Siemens primary Tier 2 and Tier 1 communication protocols
1.8.47	P	Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
1.8.48	PI	Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (Reset control).
1.8.49	PID	Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which it is changing (derivative).
1.8.50	PM	Project Manager capable of making project and personnel decisions.
1.8.51	PPD	Physical Plant Department (University of Florida)
1.8.52	Point	Analog or discrete instrument with addressable database value
1.8.53	Protocol	A set of rules and standards governing the on-line exchange of data between control systems of the same or different manufacturers.
1.8.54	Provide	To “furnish” and “install”
1.8.55	RF	Radio Frequency
1.8.56	RFI	Radio Frequency Interference
1.8.57	Router	Device for implementation of Network Layer Protocol
1.8.58	Self-Tune	Same as Auto-Tune
1.8.59	Solenoid	Electric two position actuator.
1.8.60	Software	Includes all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the control industry for real-time, on-line, integrated control system configurations.
1.8.61	Thin Client	A network computer without a hard disk drive.
1.8.62	Tier 1	LAN and/or WAN communication network. Building to building communication or high speed Ethernet communication level running within a specific building.
1.8.63	Tier 2	Building level communication or low speed tier running under a building level supervisory controller.
1.8.64	VAV	Variable Air Volume
1.8.65	VFD	Variable Frequency Drive
1.8.66	WAN	Wide Area Network
1.9	<u>Systems Description</u>	
1.9.1	Acceptable control system manufacturer :	
1.9.1.1	Siemens Industry, Inc.	
1.9.2	Scope includes labor and materials including but not limited to:	

- 1.9.2.1 Tools and other equipment
- 1.9.2.2 Software, licenses, configurations and database entries,
- 1.9.2.3 Interfaces, wiring, tubing, labeling,
- 1.9.2.4 Engineering and calculations
- 1.9.2.5 Calibration, testing, verifications, training and other services,
- 1.9.2.6 Documentation, samples, submittals,
- 1.9.2.7 Permits, professional licenses, etc.
- 1.9.2.8 Other Administrative fees such as parking, shipping, handling, etc.

- 1.9.3 Provide a complete system and be accessible via manufacturer's specific server system using a web browser interface implemented over the Owner's intranet as well as over the Internet.

- 1.9.4 The BAS network includes but is not limited to the following:
 - 1.9.4.1 Operator PCs – fixed or portable
 - 1.9.4.2 Connection to existing network servers.
 - 1.9.4.3 Communications equipment needed to support the in-building communication BAS network.
 - 1.9.4.4 Intelligent and addressable elements and end devices.
 - 1.9.4.5 Third-party equipment interfaces.
 - 1.9.4.6 Other components required for a complete and working BAS.
- 1.9.5 The BAS Network shall utilize an architecture capable of the following:
 - 1.9.5.1 Utilizing standard Ethernet communications operating at a minimum speed of 10/100 Mb/sec.
 - 1.9.5.2 The BAS network shall support both copper and optical fiber communication media at the Tier 1 level.

- 1.9.6 The BAS Network shall integrate to the following systems:
 - 1.9.6.1 Lighting [**Division 16XXX**]
 - 1.9.6.2 Power metering [**Division 16XXX**]
 - 1.9.6.3 Generator [**Division 16XXX**]
 - 1.9.6.4 Plumbing [**Division 15XXX**]
 - 1.9.6.5 Other [**Division XXXXX**]
 - 1.9.6.6 Chilled Water and Hot Water System Metering [**Division 15XXX**]

- 1.9.7 The system shall be compatible with the FSU IT network.

- 1.9.8 The BAS shall be fully expandable with the addition of hardware and/or software. Expansion shall not require removal of existing DDCP, sensors, actuators, or communication networks.

- 1.9.9 System must be of a modular design to ensure reliability and system performance.

- 1.9.10 All electrical work required as an integral part of this section is work of this section.

- 1.9.11 Provide final power connections including conduit, wire, and/or control panel disconnect switches to all control devices from appropriate electrical j-box.
- 1.9.12 Include the following integrated features, functions and services:

- 1.9.12.1 Operator information, alarm management and control functions at any operator's console without the need to purchase special software from the contractor or BAS manufacturer for those consoles.
- 1.9.12.2 Information management including monitoring, transmission, archiving, retrieval, and reporting functions
- 1.9.12.3 Diagnostic monitoring and reporting of BAS functions
- 1.9.12.4 Energy management
- 1.9.12.5 Wireless Device capability
- 1.10 Quality Assurance:
 - 1.10.1 Provide components not specifically indicated or specified, but necessary to make system function within the intent of contract documents and sequence of operation.
 - 1.10.2 All electrical products to be listed and labeled by UL and comply with NEMA Standards.
 - 1.10.3 Control wiring shall be in accordance with National Electric Code.
 - 1.10.4 The Contractor shall have qualified technicians within a 50 mile radius of Project Site and have the ability to comply with a two hour on-site response time.
 - 1.10.5 Provide a competent and experienced Project Manager with a minimum of 5 years' experience with similar projects. Include resume in submittal package.
 - 1.10.6 Engineering services shall be performed by factory-trained engineers. Include relevant documentation in submittal package.
 - 1.10.7 System shall be installed by factory trained mechanical and electrical installers either in direct employ of this Contractor or by subcontractors who are under direct supervision of this Contractor.
 - 1.10.8 Use only manufacturer trained technicians who are skilled, experienced, trained, and familiar with the specific equipment, software and configurations to be provided under this section. Include relevant documentation in submittal package.
 - 1.10.9 Coordinate with the Owner to ensure that the BAS will perform in the Owner's IT environment without disruption to any of the other activities taking place on that LAN or WAN.
 - 1.10.10 Coordinate timely delivery of materials and supervise activities of other trade contractors to install inline devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, and other such items furnished under this section but installed by other trades.
 - 1.10.11 Select sensors and transducers to most closely match the expected sensing or control range.

- 1.10.12 Mark and detail exact location of inline devices, wells, and taps to be installed by Mechanical Contractor on coordination drawings and confirm locations in the field.
- 1.10.13 Instrumentation with factory J-boxes shall not be used as junction boxes.
- 1.10.14 Install control equipment, wiring and air piping in neat and workmanlike manner to satisfaction of A/E, and in accordance with manufacturer's recommendations. Maintain clearances, straight length distances, etc. required for proper operation of each device.
- 1.10.15 Install control devices in accessible location. Coordinate all control device locations with other trade contractors. Contractor to report to A/E conditions that prevent reasonable accessibility.
- 1.10.16 Wire VFD's so that all safeties and interlocks remain operational (inclusive of isolation dampers, isolation valves, end switches, interlocks, safeties etc) when drive is placed in **[Auto, Hand or Bypass mode]**.
- 1.10.17 Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.
 - 1.10.17.1 All control devices located outdoors shall be rated for the anticipated environment.
 - 1.10.17.2 Include provisions for supplemental ventilation when control devices must be located within outdoor control panels and when control devices are not rated the planned environment.
- 1.10.18 All digital equipment furnished under this contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of Part 15 of FCC Rules.
- 1.10.19 Acceptance Criteria: The system shall report all values with an end-to-end accuracy equal to or better than those listed below: The intent of this guideline is to establish criteria for the Control Contractor and **[Commissioning Agent]** with regard to calibration and acceptance. Reference specific instrumentation sections for required accuracies.

<u>Measured Variable</u>	<u>Criteria</u>
Space Temperature	+/- 1.0°F
Ducted Air (Single Probe)	+/- 0.5°F
Ducted Air (Averaging)	+/-2.0 °F
Outside Air	+/- 1.0 Deg F
Dew Point	+/- 2.0 Deg F
Water Temp	+/- 0.5°F
Relative Humidity (duct and space)	+/- 5% RH
Water Flow	+/- 5% (GPM) of reading
Air Flow (Terminal unit)	+/- 5% (CFM) of reading
Air Flow (Measuring Station)	+/- 5% (CFM) of full scale
Air Pressure (ducts)	+/- 0.10 in WC
Air Pressure (space)	+/- 0.01 in WC

Water Pressure	+/- 2% (psig/psid) of reading
Electrical (A, V, W, PF)	5% of reading
Carbon Monoxide (CO)	+/- 5% of reading
Carbon Dioxide (CO2)	+/- 75 ppm

1.10.19.1 Stability of Control: Control loops shall maintain measured variable at setpoint within the tolerances listed below and shall, upon any change to the feedback variable recover within 5 minutes of the initial event. The intent of this guideline is to establish criteria for the Control Contractor, A/E, and **[Commissioning Agent]** with regard to control loops and acceptance.

<u>Controlled Variable</u>	<u>Control Accuracy</u>	<u>Range of Medium</u>
Air Pressure (ducts)	+/- 0.2 in WC	-6 to +6 in WC
Air Pressure (room)	+/- 0.010 in WC	-0.100 to +0.100 in WC
Air flow	+/- 100 CFM or 1% of setpoint (whichever is less)	
Temperature	+/- .5 Deg F	
Room Temperature	+/- 1.0 Deg F	
Humidity	+/- 3% RH	
Fluid Pressure	+/- 1.0 psi/psid	1 to 150 psi/psid
Carbon Dioxide (CO2)	+/- 50 ppm	100 to 2000 ppm

1.10.20 Provide all points required to implement control sequences specified, whether or not they are listed in schedules.

1.10.21 All outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return, relief air, smoke dampers, heating valves, cooling valves, etc., shall each have a separate output.

1.10.22 Point and Alarming expectations: The system shall include points and alarms as described in Contract Drawings.

1.11 Commissioning:

1.11.1 Assist Testing Adjust Balance Contractor in verifying system operation for all modes of operation.

1.11.2 Demonstrate the sequence of operation for each system and/or sub-system to **[Commissioning Agent (CxA) and/or Engineer]**. Perform all other requirements and perform all services as required in Cx specification Section **[(#####) Commissioning Requirements]**.

1.11.2.1 Use vendor specific forms and **[Owner/3rd Party Cx Agent]** documentation to document the operation and performance of all control systems.

1.11.2.2 Demonstrate functional tests for each point, control sequence, and control loop.

- 1.11.2.3 Provide trends, schedules, printouts, etc to **[Cx Agent/Engineer]** as requested to document system performance.
- 1.12 Submittals:
- 1.12.1 Organized submittals based on specification numbers with major tabs to separate major sections and a master index indicating all elements of submittal.
- 1.12.2 Identify specific parts and accessories proposed for project. Order submittals based on the specification section and include the following:
- 1.12.2.1 BAS network architecture diagrams including all Tier 1 nodes, Tier 2 interconnections, and 3rd party integration. Include repeater locations.
- 1.12.2.2 Provide floor plans locating all control units, workstations, servers, LAN interface devices, gateways, etc. Include all Tier 1 and Tier 2 communication wiring routing, power wiring, power originating sources, and low voltage power wiring. 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 LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. As-built wire routing conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
- 1.12.2.3 Schematic flow diagram of system showing all equipment and control devices. Diagram shall include designation of all inline devices, wells, taps and other devices furnished under this Section but installed by other trades.
- 1.12.2.4 Identification of immersion wells, pressure taps, associated shut-off valves, flow switches, level switches, flow meters, air flow stations and other such items furnished under this section but installed by other trades.
- 1.12.2.5 Setting or adjustable range of control for each control device.
- 1.12.2.6 Written description of detailed sequence of operations. Include all initial set-point values, time delay values, references to specific device names. The sequences shall be detailed and include all vendor specific pre-engineered logic. They should not be a duplication of the Engineer's sequences.
- 1.12.2.7 Points schedule for each real point in the BAS, including: Tag, Point Type, System Name and Display Units. Device Type, Address, Cable Destination, Module Type, Terminal ID, Panel, Slot Number, Reference Drawing, and Cable Number. Cable destination, terminal ID, slot number, etc... may also be identified in panel detail drawings.
- 1.12.2.8 Samples of each typical system Graphic Display screen and associated menu penetrations to show hierarchy and functional interrelationships for systems specified. Sample floor plan graphic showing all proposed components and colors.
- 1.12.2.9 Detailed Bill of Material list for each system, identifying quantity, part number, description, and optional features selected.

- 1.12.2.10 Relevant resumes and documentation for proposed project team members.
- 1.12.2.11 Control Dampers
 - 1.12.2.11.1 Schedule including a separate line for each damper and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Frame Type, Blade Type, Bearing Type, Seals, Duct Size, Damper Size, Mounting, Actuator Type, Actuator model number, Actuator torque rating and quantity of actuators required to ensure total closure of damper(s).
 - 1.12.2.11.2 Leakage and flow characteristics data for all control dampers. Leakage ratings to be based on AMCA Standard 500 and dampers to bear AMCA leakage certification seal.
- 1.12.2.12 Control valve schedules including a separate line for each valve and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Actual Valve CV, Calculated CV, Design Pressure drop, Actual Pressure drop, Actuator Type and model number.
- 1.12.2.13 Room Schedule including a separate line for each terminal unit indicating terminal identification, minimum/maximum cfm, box area, thermostat/sensor location, Htg/Clg Setpoints and bias setting. The schedule shall include typical calibration factors to be filled in by TAB contractor during startup and verification.
- 1.12.2.14 Air Flow Measuring System Schedule including a separate line for each flow device and column for device type, model number, size, location.
- 1.12.2.15 Cabling indicate all required electrical wiring. Information including wire jacket colors for low voltage signal wiring, low voltage power wiring and communication cable. Indicate wire gauge for each type of cable.
- 1.12.2.16 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. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring which is existing, factory-installed and portions to be field-installed.
- 1.12.2.17 FCC compliance.
- 1.12.2.18 Training Plan – The Contractor shall submit a written training plan to the **[Owner, A/E, CxA]** for review and approval prior to training. The plan shall include the following elements:
 - 1.12.2.18.1 Equipment (included in training)
 - 1.12.2.18.2 Intended audience
 - 1.12.2.18.3 Location of training

- 1.12.2.18.4 Objectives
- 1.12.2.18.5 Subjects covered (description, duration of discussion, special methods, etc.)
- 1.12.2.18.6 Duration of training on each subject
- 1.12.2.18.7 Instructor name and qualifications for each subject
- 1.12.2.18.8 Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.) Training to be recorded by Contractor (Construction Manager)
- 1.12.2.19 Integration Plan
 - 1.12.2.19.1 Coordination of vendor protocol and point list submission.
 - 1.12.2.19.2 Workflow processes to integrate systems.
 - 1.12.2.19.3 Include communication hardware, software, and protocols to implement full systems integration.
 - 1.12.2.19.4 Identify proposed enhancements or deviations from project documents. Include specific drawings or specifications impacted.
 - 1.12.2.19.5 Provide coordination information to accommodate complete integration of systems including:
 - 1.12.2.19.5.1 Vendor protocol requirements.
 - 1.12.2.19.5.2 Vendor point list, cross referenced to proposed BAS point list
 - 1.12.2.19.5.3 Edit integration requirements and cross reference integration requirements with other sections.
- 1.12.3 Operating and Maintenance Manuals:
 - 1.12.3.1 Include descriptions of maintenance for all components supplied under this section, including (but not limited to) sensors, actuators and controllers.
 - 1.12.3.2 Include inspection requirements, periodic preventative maintenance recommendations, fault diagnosis, instructions for repair or replacement of defective components, calibration instructions, parts lists, name, address, and phone number of manufacturer's representative.
 - 1.12.3.3 Provide product operational and maintenance data in electronic PDF format (Acrobat latest version- 9.0 or greater) on vendor specific server, and provide means to access this data using intuitive operator interaction (quick links from main system graphics).
 - 1.12.3.3.1 Include name and 800 number of a 7 day a week 24 hour a day service line for needed service during the first year of operation
 - 1.12.3.4 Software Tab Section:

- 1.12.3.4.1 As part of operating and maintenance manuals include a software tab. Divide this software tab section into separate parts with tabs for each part. A separate CD including all required information shall be included under this tab section which shall include the following:
- 1.12.3.4.1.1 As-built sequence of operation provided in Microsoft Word format.
 - 1.12.3.4.1.2 All building level and system level programs. Application specific programs shall include all configuration files showing final menu selections and applicable default settings.
 - 1.12.3.4.1.3 Describe general operating procedures, starting with system overview and printed graphic displays of all systems and provide trend graphs of all control loops with a minimum 24 hour trend at five minute intervals.
 - 1.12.3.4.1.4 Where applicable the Contractor shall provide the latest Factory standard technical manuals in CD and hard copy format. Confirm existing FSU Facilities technical manuals are the latest versions for the systems provided under this project.
 - 1.12.3.4.1.5 Software Backup: Upon successful completion of acceptance testing, include in this section, one archive copies of all accepted versions of source code and compiled code for all application programs and data files on compact disc media. All control software must be readily accessible by Owner using BAS server hardware and software. Software file naming for ASC controllers shall match ID reference on mechanical drawing – ID reference will be unique.
- 1.12.3.5 Record Drawings:
- 1.12.3.5.1 Submit as-built shop drawings indicating all changes made during project. The drawing files shall be in Adobe .pdf format and original control format software such as Visio or AutoCAD.
 - 1.12.3.5.1.1 Install all as-built control drawings (and associated sequence of operation) in electronic format on specific server, and provide means to access this data using intuitive interaction by end users.
 - 1.12.3.5.1.2 Each system web page shall allow for an automatic link to the associated control diagram product O&M data sheets and sequence of operation. Mark specific products and options used on project when posting product data sheets. Provide operator a way to access product and as-built control information from the associated system web page (e.g. AHU system, chilled water system, hot water system, VAV system, etc...)
 - 1.12.3.5.2 Mount (within control panel) laminated control flow drawing, sequence, point schedule and control panel wiring diagrams indicating all field points connected.
 - 1.12.3.5.2.1 The control panel wiring diagrams shall utilize the same field device tag names used within the associated control diagram and graphic interface.
 - 1.12.3.5.2.2 Not required for room level controllers.
- 1.13 Warranty:

- 1.13.1 At the end of final startup, testing, and commissioning phase, if equipment and systems are operating satisfactorily, the A/E and each of the University's agents shall certify that the controls system's operation has been tested and accepted in accordance with the terms of this specification. The date of such certification shall be the start of the warranty period(s).
- 1.13.2 Submit warranty documentation upon substantial completion of project or phase (if applicable) and acceptance by Engineer and Owner.
- 1.13.3 Repair or replace systems or parts found defective at no cost to Owner during the warranty period.
- 1.13.4 Include parts, labor, and necessary travel during warranty.
- 1.13.5 Provide vendor specific and 3rd party warranty and registration information as applicable.
- 1.13.6 Provide services incidental to proper performance.
- 1.13.7 First year of warranty includes parts and labor for entire system (including 3rd party equipment). Adjust, repair, or replace, at no additional cost to the owner, control system failures during the 1st year (includes software issues).
- 1.13.8 Second year of warranty includes parts only.
- 1.13.8.1 Provide a minimum two year warranty for all parts (including 3rd party equipment) provided under this section. Warranty includes all cost to cover defective hardware replacement of like or equal product.
- 1.13.9 Warranty response time shall be as indicated. The designated FSU Facilities representatives representing the operations and service departments shall be the authorized callers and will determine the required response level.
- 1.13.9.1 Emergency service - must respond within two hours of being notified.
- 1.13.9.2 General warranty service - must respond within 4 hours of being notified.
- 1.13.9.3 Scheduled service – must respond within 48 hours of being notified.
- 1.13.10 Include server software, project-specific software, graphic software, database software, and firmware updates/patches which resolve known software deficiencies at no additional charge, during the 2 year warranty period.
- 1.14 Owner Instruction:
- 1.14.1 Training Requirements:
- 1.14.1.1 The following summarizes the required training tasks and objectives for the systems provided under this section. The scope and duration shall be determined by the Contractor and shall be commensurate to the project scope and complexity. The Contractor shall include the following elements:

1.14.1.1.1 Review BAS deliverables with respect to general content and organization:

- 1.14.1.1.1.1 Operations and Maintenance manuals.
- 1.14.1.1.1.2 As-Built Control Drawing Package
- 1.14.1.1.1.3 Graphical User Interface
- 1.14.1.1.1.4 Reporting packages and content
- 1.14.1.1.1.5 As-Built Control Sequences
- 1.14.1.1.1.6 Maintenance service agreements, state of warranty date and similar continuing commitments.
- 1.14.1.1.1.7 Review location of all BAS equipment / panel locations

1.14.1.1.2 Operations:

- 1.14.1.1.2.1 Startup procedures.
- 1.14.1.1.2.2 All equipment or system start-up procedures.
- 1.14.1.1.2.3 All equipment or system shut-down procedures.
- 1.14.1.1.2.4 Routine and normal operating sequence for all systems.
- 1.14.1.1.2.5 Special operating instructions and procedures not addressed above.
- 1.14.1.1.2.6 Seasonal and weekend operating instructions.
- 1.14.1.1.2.7 Software backup procedures and file locations

1.14.1.1.2.8 Emergencies:

- 1.14.1.1.2.8.1 Instructions on meaning of warnings, trouble indications, and error messages.
- 1.14.1.1.2.8.2 Instructions on stopping, manual overrides and BAS override procedures.
- 1.14.1.1.2.8.3 Safety device procedures and actions.
- 1.14.1.1.2.8.4 Operating procedures for system, subsystem, or equipment failure.
- 1.14.1.1.2.8.5 Shutdown instructions for each type of emergency.
- 1.14.1.1.2.8.6 Operating instructions for conditions outside of normal operating limits.
- 1.14.1.1.2.8.7 Special operating instructions and procedures.

1.14.1.1.2.9 Adjustments:

- 1.14.1.1.2.9.1 Proper adjustment procedures and points intended to be adjusted
- 1.14.1.1.2.9.2 Economy and efficiency adjustments.
- 1.14.1.1.2.9.3 Adjustments for efficient energy use.

1.14.1.1.2.10 Troubleshooting:

- 1.14.1.1.2.10.1 Diagnostic instructions procedures for each typical system installed.
- 1.14.1.1.2.10.2 Test and inspection procedures for each typical system installed.

1.14.1.1.2.11 Maintenance:

- 1.14.1.1.2.11.1 Inspection procedures.
- 1.14.1.1.2.11.2 Types of cleaning agents to be used and methods of cleaning.
- 1.14.1.1.2.11.3 Procedures for calibration.
- 1.14.1.1.2.11.4 Procedures for preventive maintenance.
- 1.14.1.1.2.11.5 Procedures for routine maintenance.
- 1.14.1.1.2.11.6 Instruction on use of special tools.

1.14.1.1.2.12 Repairs:

1.14.1.1.2.12.1 Diagnosis and repair instructions.

1.14.1.1.2.12.2 Disassembly; component removal, repair, and replacement; and reassembly instructions.

1.14.1.1.2.12.3 Instructions for identifying parts and components.

1.14.1.1.2.12.4 Review of spare parts needed for operation and maintenance.

1.14.2 In addition to the initial project training requirements above, the Contractor shall include an additional [16] hours of training to be delivered in accordance with FSU Facilities requirements.

2 PRODUCTS

2.1 Software:

2.1.1 Data Storage and Archiving:

2.1.1.1 Trend data shall be stored at the stand alone BLC/AAC panels, and uploaded automatically to server hard disk storage when archival is desired or when local trend storage capacity drops below 20%. All all critical points or controlled points shall be trended and stored on Vendor specific server. Storage capacity shall be based on an initial sample rate for all points at 15 minutes. Server capacity shall support a minimum five years of trend data. The contractor is responsible for upgrading existing server as needed to support the additional project points and required memory. Ensure the server will maintain no less than 100% spare capacity.

2.1.2 Control Software Description for BLC/AAC include:

2.1.2.1 The ability to perform the following pre-tested stand-alone control algorithms:

2.1.2.1.1 Two-position control

2.1.2.1.2 Proportional control

2.1.2.1.3 Proportional plus integral control

2.1.2.1.4 Proportional, integral, plus derivative control

2.1.2.1.5 Automatic tuning of control loops with enable/disable capabilities

2.1.2.1.6 Equipment Cycling Protection: Include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.

2.1.2.1.7 Heavy Equipment Delays: Provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads (user selectable).

2.1.2.1.8 Power Fail-Motor Restart: Upon the resumption of normal power, the BLC/AAC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation.

- 2.1.2.2 The ability to perform all of the following energy management routines:
 - 2.1.2.2.1 Time-of-day scheduling
 - 2.1.2.2.2 Calendar-based scheduling
 - 2.1.2.2.3 Holiday scheduling
 - 2.1.2.2.4 Temporary schedule overrides
 - 2.1.2.2.5 Start-Stop Time Optimization
 - 2.1.2.2.6 Automatic Daylight Savings Time Switch-over
 - 2.1.2.2.7 Night setup and setback control
 - 2.1.2.2.8 Enthalpy switch-over (economizer)
 - 2.1.2.2.9 Peak demand limiting
 - 2.1.2.2.10 Totalization (runtime, flow, Btu...)
- 2.1.2.3 Read and display the value of any property, including all required properties, supported optional properties, and proprietary extensions of every object located within each networked device.
- 2.1.2.4 The ability to execute custom, job-specific processes to automatically perform calculations and special control routines.
 - 2.1.2.4.1 Incorporate measured or calculated data from other DDC controllers on the network.
 - 2.1.2.4.2 Issue commands to points in other DDC controllers on the network.
 - 2.1.2.4.3 Support 30 characters, English language point names, structured for searching and logs.
 - 2.1.2.4.4 Directly send a text message to a specified device or cause the execution of an alarm message at any connected thin client PC, dial-up connection to a remote device or cause the execution of a remote connection to a remote device such as a printer, pager, PDA or cell phone.
 - 2.1.2.4.5 Include a HELP function key.
 - 2.1.2.4.6 Incorporate comment lines for program clarity.
- 2.1.3 Alarm management:
 - 2.1.3.1 Monitor and direct alarm information to operator devices.
 - 2.1.3.2 Generate custom written operator alarm message (to be developed by the Contractor and Owner in conjunction with the project) and advisories to operator I/O devices.
 - 2.1.3.3 Perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost.
 - 2.1.3.3.1 At no time shall the ability of the BLC/AAC to report alarms be affected by either a remote PC, local I/O device or communications with other panels on the network.

- 2.1.3.3.2 All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
- 2.1.3.4 Authorized users shall have the ability to manually inhibit alarm reporting for each point.
- 2.1.3.5 Alarm destinations shall be included so that alarms are indicated and printed at a pre-defined FSU reporting device, or transaction log.
 - 2.1.3.5.1 Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hour's destinations) and/or based on priority.
 - 2.1.3.5.2 Alarms shall directly send an alarm message to specified client PC destination or cause the execution of a connection to a remote device (owner to designate) and cause the execution of a communications connection to a remote wireless device (pager, hand held, email or Pocket PC device).
 - 2.1.3.5.3 Alarm messages, and point graphic assignments alarms shall have accurate descriptions and response instructions, so that alarms may be quickly associated with appropriate graphic display.
- 2.1.3.6 Alarm reports shall be sent to multiple WEB connected PC's, cell phones or PDA's and shall send alarm reports.
- 2.1.4 A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for points as specified in the I/O summary.
 - 2.1.4.1 Any point, physical or calculated shall be capable of trending.
 - 2.1.4.2 Any point, regardless of physical location on the network, may be collected and stored in each BLC/AAC point group.
 - 2.1.4.3 Two methods of collection shall be allowed: either by a pre-defined schedule or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided.
 - 2.1.4.4 Each BLC/AAC shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
 - 2.1.4.5 BLC/AAC units shall provide high resolution sampling capability for verification of control loop performance.
 - 2.1.4.6 Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
- 2.1.5 BLC/AAC units shall be capable of automatically accumulating and storing run time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.
- 2.1.6 The building level network shall allow the BLC/AAC units to access any data from or send control commands and alarm reports directly to any other BLC/AAC or combination of

- controllers on the network without dependence upon a central or intermediate processing device.
- 2.1.7 The building level network shall also allow any BLC/AAC to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
- 2.1.8 Failsafe hardware shall be provided such that BAS failures result in immediate return to local control. If the controller uses database values from other controllers, and the communication network fails or malfunctions, control loop outputs shall continue to function using last value received from BAS.
- 2.1.9 The BLC/AAC shall automatically call for a new database download from the server upon loss or corruption of a database. An operator with sufficient access privileges may in addition, activate a database download manually from the server.
- 2.2 **Building Level Controller (Primary interface between building Tier1/Tier2 controllers and FSU WAN):**
- 2.2.1 BLC units shall be a general purpose multiple application direct digital controller (DDC) used to manage global programs, complex system control, local data storage, building level communications, and remote server interface.
- 2.2.1.1 Controller size shall be sufficient to fully meet the requirements of this specification. Controllers at Tier 2 level shall not exceed 75% of available trunk capability.
- 2.2.2 The BLC shall perform the function of monitoring all system variables, including but not limited to:
- 2.2.2.1 Hardware points, software points and controller parameters such as setpoints.
- 2.2.2.2 The BLC shall manage and direct all information traffic on the Tier 1 network, between the Tier 1 and Tier2 networks, and to servers.
- 2.2.2.3 Each BLC shall be able to extend its performance and capacity through the use of Advanced Application Controllers (AAC) and remote Application Specific Controllers (ASC's).
- 2.2.2.4 BLC shall provide an RS-232C serial data communication port or Ethernet RJ45 connection for operation of local operator I/O devices independent of the LAN used for primary access, such as industry standard printers, operator terminals, modems and portable laptop operators/terminals. BLC shall allow temporary use of portable devices without interrupting the normal operation of permanently connected Ethernet, modems, printers or terminals.
- 2.2.2.5 Each BLC shall have sufficient memory to support its own operating system and databases, Including:
- 2.2.2.5.1 Control processes
- 2.2.2.5.2 Energy management applications
- 2.2.2.5.3 Alarm management applications including custom alarm messages for each level of alarm for each point in the system:
- 2.2.2.5.4 Historical / trend data for points specified

- 2.2.2.5.5 Maintenance support applications
- 2.2.2.5.6 Custom processes
- 2.2.2.5.7 Operator I/O
- 2.2.2.5.8 Ethernet/Dial-up communications
- 2.2.2.5.9 Manual override monitoring

- 2.2.2.6 Configuration and Download: The BLC shall have the capability of receiving configuration and program loading by means of the following: 1) locally, via a direct connect portable laptop service tool or USB port, 2) over the network, from the portable laptop service tool, and 3) from the server or associated thin client PC, via the communication networks.

- 2.2.2.7 Configuration and Upload: The BLC shall have capabilities of uploading configurations program to be archived on local operator terminal and/or remote server.

- 2.2.2.8 Each BLC shall contain both software and firmware to perform global control strategies.

- 2.2.2.9 Each BLC shall continuously perform self-diagnostics, including communication diagnosis of all panel components. The BLC shall provide both local and remote annunciation of any detected component failures, low battery condition or repeated failure to establish communication.

- 2.2.2.10 Isolation shall be provided at all peer-to-peer network terminations, as well as all field point termination's to suppress voltage transients consistent with ANSI/IEEE Standard c62.41 – 1983.

- 2.2.2.11 In the event of the loss of normal power, there shall be an orderly shutdown of all BLC's to prevent the loss of database or operating system software.
 - 2.2.2.11.1 Upon restoration of normal power, the BLC shall automatically resume full operation without manual intervention. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.
 - 2.2.2.11.2 Should BLC memory be lost for any reason, the user shall have the capability of reloading the BLC via the local RS-232C port or from an Internet client or server PC.
 - 2.2.2.11.3 **[All BLC units shall include an internal or external UPS power supply unit to insure reliability of network communications through any power outage event. UPS shall be sized for 50% spare capacity. The UPS shall be complete with batteries, external bypass and line conditioning].**

- 2.2.2.12 The BLC shall be capable of direct connection to multiple field busses.

- 2.3 Advanced Application Controllers-Hardware (AAC) (AHU ##, EF ##, Heating Hot Water, Chilled Water, etc...)
 - 2.3.1 AAC units shall be a general purpose multiple application direct digital controller (DDC) used to manage complex system control, local data storage, and building level communications.

- 2.3.2 At minimum, Include the following:
 - 2.3.2.1 AAC shall be capable of operating in a stand-alone capacity, or within a Tier 1 or Tier 2 environment.
 - 2.3.2.2 Support non-volatile flash memory, input/output, 12 bit A to D conversion, hardware clock/calendar and voltage transient and lightning protection devices.
 - 2.3.2.3 Include full multi-tasking, multi-user real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.
 - 2.3.2.4 Include firmware revisions to the module shall be made from the central server remotely over the Intranet.
 - 2.3.2.5 Each AAC shall accommodate multiple I/O expansion via a designated expansion I/O bus port.
- 2.3.3 Each AAC shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).
- 2.3.4 Each AAC shall provide an RS-232C/RS-485 serial data communication port for operation of local operator I/O devices independent of the LAN used for primary access, such as industry standard printers, operator terminals, modems and portable laptop operators/terminals.
 - 2.3.4.1 Allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
 - 2.3.4.2 The operator shall have the ability to manually override DO automatic or centrally executed commands at the AAC via local terminal or controller DO manual H/O/A point for digital control type points. Relay override, starter override, or VFD override may satisfy this requirement if feedback is included.
 - 2.3.4.2.1 Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
 - 2.3.4.2.2 Monitor the status of all overrides and inform the operator that automatic control has been inhibited. The AAC shall also collect override activity information for reports.
 - 2.3.4.2.3 The operator shall have the ability to manually override AO automatic or centrally executed commands at the AAC via local display terminal or controller AO manual Hand/Auto point for analog control type points. Local terminal display unit (IF USED) shall be permanently installed in each AAC panel and shall be password protected.
 - 2.3.4.2.4 Override switches shall be mounted within the AAC'S key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. Local display units shall be password protected.

- 2.3.4.2.5 The AAC shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. The AAC shall also collect override activity information for reports.
- 2.3.4.3 Each AAC shall have sufficient memory to support its own operating system and databases, Including:
 - 2.3.4.3.1 Control processes
 - 2.3.4.3.2 Energy management applications
 - 2.3.4.3.3 Alarm management applications including custom alarm messages for each level of alarm for each point in the system
 - 2.3.4.3.4 Historical / trend data for points specified
 - 2.3.4.3.5 Maintenance support applications
 - 2.3.4.3.6 Custom processes
 - 2.3.4.3.7 Operator I/O
 - 2.3.4.3.8 Manual override monitoring
- 2.3.4.4 Configuration and Download: The AAC shall have the capability of receiving configuration and program loading by means of the following: 1) locally, via a direct connect portable laptop service tool, 2) over the network, from the portable laptop service tool, and; 3) from the server or associated client PC, via the communication networks.
- 2.3.4.5 Configuration and Upload: The AAC shall have capabilities of uploading configurations program to be archived on local operator terminal and remote server.
- 2.3.4.6 Each AAC shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.
- 2.3.4.7 Each AAC shall continuously perform self-diagnostics, including communication diagnosis of all panel components. The AAC shall provide both local and remote annunciation of any detected component failures, low battery condition or repeated failure to establish communication.
- 2.3.4.8 Isolation shall be provided at all peer-to-peer network terminations, as well as all field point termination's to suppress voltage transients consistent with ANSI/IEEE Standard c62.41 - 1983.
- 2.3.4.9 In the event of a loss of normal power, there shall be an orderly shutdown of all AAC'S to prevent the loss of database or operating system software. Nonvolatile flash type memory shall be incorporated for all critical controller configurations and battery backup shall be provided to support the real-time clock and volatile memory for a minimum of 72 hours.
 - 2.3.4.9.1 Upon restoration of normal power, the AAC shall automatically resume full operation without manual intervention. Vendor / Installer shall add custom programming to sequentially start all controlled equipment with a time delay between each command.
 - 2.3.4.9.2 Should AAC memory be lost for any reason, the user shall have the capability of reloading the controller via the local RS-232C port or from an Internet client or server PC.

- 2.3.4.9.3 **[All AAC units shall include an internal or external UPS power supply unit to insure reliability of network communications through any power outage event. UPS shall be sized for 50% spare capacity. The UPS shall be complete with batteries, external bypass and line conditioning.]**
- 2.3.4.10 All AAC units shall be expandable and shall act as one control unit. In addition to the specified I/O point requirements and capacity requirements the Contractor shall provide two spare DI's, DO's, AI's, and AO's per panel.
- 2.4 Application Specific Controllers (ASC'S) (VAV ##, FCU #, Laboratory Control)
- 2.4.1 Performance and capacity of AAC/BLC units shall be extended through the use of stand-alone remote ASC'S for VAV terminals, fan coil units, unit ventilators, heat pumps, small single zone air handlers etc.
- 2.4.1.1 Controllers shall be capable of field configuration and program uploads and downloads.
- 2.4.1.2 Controllers shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network.
- 2.4.1.3 Controllers shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- 2.4.2 Alarm Management: Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.
- 2.4.3 ASC'S shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 4-20ma proportional signals, 0-5 Vdc or 0-10 Vdc proportional signals allowing for interface to a variety of modulating actuators.
- 2.4.4 VAV Terminal Controllers
- 2.4.4.1 The unit controller used for VAV applications shall support the air terminal unit used as the basis of design for this project, including the air terminal unit damper actuator and multi-point, center averaging velocity sensor. The controller shall be capable of controlling the air terminal unit in all control strategies as described in contract documents.
- 2.4.4.2 Setpoints, flow limits, and occupancy schedules shall be maintained indefinitely in each controller's non-volatile memory. No batteries shall be required.
- 2.4.4.3 It shall be possible to monitor flow in CFM and to adjust flow limits, temperature setpoints, and schedules, without direct access to the terminal unit, by plugging in a standard laptop computer or PDA device at the room temperature sensor.
- 2.4.4.4 Each controller shall control by modulating the terminal unit electrically actuated device(s) using a proportional/integral (PI) algorithm with programmable PI coefficients.
- 2.4.4.5 If required by the sequence of operation, ASC's used as a VAV terminal unit controller shall be able to accept a relay input from an occupancy sensor. This input shall toggle the air

- terminal unit between occupied and unoccupied modes and override occupied/unoccupied scheduling information the air terminal unit receives from the BLC or AAC.
- 2.4.4.6 Location of terminal unit to be indicated on ceiling grid. Use a permanent tag engraved with Box Number and Room Number of thermostat location. Use black lettering with white background.
- 2.4.4.7 Provide a means of automatically disconnecting the differential pressure sensing lines to ensure a true no flow condition during automatic recalibration events.
- 2.5 Control Wiring and Pathways:
- 2.5.1 All cables (< 50 VAC/VDC) used within control system shall contain an overall jacket (plenum rated).
- 2.5.2 Refer to Section [16XXX] for conductors, except as noted.
- 2.5.3 Refer to Section [16XXX] for pathways except as noted.
- 2.5.4 Instrumentation I/O Conductors (<50 Volts and Under):
- 2.5.4.1 No wire smaller than #18 AWG shall be used unless otherwise specified such as thermostat wiring.
- 2.5.4.2 Provide isolated instrument grounding system per manufacturer's recommendations and project requirements.
- 2.5.4.3 Conductors shall have UL listed plenum rated teflon insulation.
- 2.5.5 Communication Cable:
- 2.5.5.1 Manufacturer approved cable labeled "BAS Communication" no less than 10 ft. intervals. Provide additional shielding and grounding per applicable manufacturer's recommendations and/or job site conditions. Conductors shall have UL listed plenum rated teflon insulation.
- 2.6 Air Piping:
- 2.6.1 Copper Tubing:
- 2.6.1.1 Type L, hard or soft seamless, ASTM B88, wrought copper soldered fittings, ANSI B16.22 except at connections to apparatus, where brass compression-type fittings shall be used.
- 2.6.1.2 Solder joints shall be made with ASTM B32, 95-5 tin-antimony solder-joint, Bridgit or Silvabrite.
- 2.6.2 Plastic Tubing:
- 2.6.2.1 Fire resistant virgin polyethylene, meeting stress-crack test ASTM D1693-60T.

2.6.2.2 Individual tube polyethylene or multi-tube instrument tubing bundle shall be classified as flame retardant under UL 94 and polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D 635.

2.6.3 Isolation valves for air piping to be threaded or soldered, two piece, bronze ball valves. Valves shall be suitable for intended service and pressure.

2.7 Air Supply System

2.7.1 Central Supply Source:

2.7.1.1 Control air will be supplied from the existing central campus main air pneumatic system at approximately 80 psig (when available).

2.7.2 Air Compressor Assembly:

2.7.2.1 Manufacturers: Quincy, Ingersol Rand.

2.7.2.2 Assembly shall be duplex type complete with air storage tank, automatic tank drain trap, belt guards, gauges, low resistance sub-micron type intake air filter and silencer, safety valve and all necessary accessories including automatic start-stop pressure switches. Furnish necessary reducing valves to reduce pressure to that required for automatic control purposes with integral relief valve. Mount compressors on single air storage tank or base mounted compressors with separate tank as required.

2.7.2.3 Air storage tank to be ASME constructed and stamped for pressure 50 percent greater than operating pressure but not less than 150 psig.

2.7.2.4 Air intake silencer to have minimum 35 dB attenuation capability at 2000 HZ frequency.

2.7.2.5 Provide vibration isolation per FSU Design and Construction Standards.

2.7.2.6 Each compressor and storage tank shall provide sufficient supply air to entire control system while operating no more than 1/3 of time with maximum of 3 starts per compressor per hour and maximum of 6 total compressor starts per hour for entire compressor system.

2.7.2.7 Motors shall be [XXX] volt, 3 phase, or [XXX] volt, single phase provided with magnetic starter, fusible disconnect and proper overload protection. Provide automatic alternator, which shall switch lead compressor after each running cycle. Alternator shall be capable of bringing on both compressors if one cannot handle load, and either shall continue to function on failure of the other.

2.7.3 Refrigerated Air Dryer Assembly:

2.7.3.1 Manufacturers: Hankison Model 8010, 8015 or 8025, Ingersol Rand.

2.7.3.2 Refrigerated air dryer assembly shall be complete with pressure regulator (single or dual), filter station, 3-way bypass valve, automatic drain, power-on status light, high temperature alarm light, and safety pressure relief. Air capacity shall be 120% of compressor system capacity. Dryer shall have hot gas bypass control to maintain continuous operation and

- constant dew-point control. Outlet dew-point shall be not higher than 38°F at 20 psig main pressure.
- 2.7.3.3 Filter assembly shall be housed in clear plastic and be replaceable element type. Filter rating shall remove 99% of total oil present, 100% of solid particles .6 micron or larger, 98% of solid particles .4 micron or larger.
- 2.8 Local Control Panels
- 2.8.1 Local control panels shall be constructed of steel, high strength composite, or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color. Construction shall comply with NEMA 1 standards for interior panels, NEMA 4 for exterior panels.
- 2.8.2 Panel mounted controlling instruments, temperature indicators, relays, switches and gauges shall be factory installed and permanently labeled. Devices shall be located inside or flush mounted on face of panel.
- 2.9 Network Routers & Bridges:
- 2.9.1 The BAS shall use the campus Wide Area Network (WAN) for communication to the campus vendor specific server.
- 2.9.2 The communication between the central server and the buildings DDC controllers shall be Siemens P2.
- 2.10 Electrical Power Meter:
- 2.10.1 Manufacture Siemens DEM
- 2.10.2 Insulation Class 600VAC†
- 2.10.3 Sample Rate 1280Hz.
- 2.10.4 Internal Isolation 2500VAC
- 2.10.5 Operating Temp. Range 0 to 50°C (<95%RH, non-condensing)
- 2.10.6 Storage Temp. Range -40°C to 70°C
- 2.10.7 Systems Accuracy ±1% of reading from 2% to 100% of the rated current of the CTs. accomplished by matching the CTs with a meter and calibrating them as a system.
- 2.10.8 Power Consumption 50VA
- 2.10.9 Electrical Services:
- 2.10.9.1 Any service where the phase A-N voltage is ≤300VAC and the phase -to-phase voltage is ≤480VAC nominal with neutral

- 2.10.9.2 Frequency 50/60Hz.
- 2.10.9.3 Protection Class NEMA 1
- 2.11 Servers:
- 2.11.1 Servers are existing
- 2.12 Control Valves:
- 2.12.1 General:
- 2.12.1.1 Use 2 port (normally open or closed based on sequence of operation) or 3 port ball type valves for control unless otherwise noted.
- 2.12.2 Globe Valves (Steam Control Applications Only):
- 2.12.2.1 Valves shall be bronze or brass body, threaded, 150 psi rating for 2" and smaller, iron body bronze mounted, flanged, 125 psi rating for 2-1/2" and larger.
- 2.12.2.2 Valves shall have stainless steel stems, spring-loaded teflon packing, replaceable seats and discs.
- 2.12.3 Ball Valves (Hot Water and Cooling Coil Applications)
- 2.12.3.1 Valves shall be bronze or brass body, 150 psi rating. Ball valves larger than 4" are not permitted.
- 2.12.3.2 Valves shall have stainless steel ball and stem, valve stem seals with dual EPDM O-Rings, rangeability must be greater than 150:1, and shall have equal percentage flow characteristics.
- 2.12.4 Butterfly Valves (Hot Water and Cooling Coil Applications 4" and larger)
- 2.12.4.1 Butterfly valves may be used for water system control valves 4" and larger provided that valves meet pressure and temperature requirements.
- 2.12.4.1.1 High performance butterfly valves shall be used for modulating applications.
- 2.12.4.1.2 General-purpose butterfly valves may be used for two-position control.
- 2.12.5 Solenoid Valves:
- 2.12.5.1 Brass or bronze body. Valves shall be selected to match required temperatures and pressure, and shall have materials which are compatible with intended working fluid.
- 2.12.5.2 All line voltage actuators shall be Class "H" (high temperature) and listed by UL or CSA.
- 2.13 Control Dampers

- 2.13.1 General:
- 2.13.1.1 If control damper sizes are not shown or scheduled, refer to Part 1 of this Section for sizing criteria.
- 2.13.1.2 Modulating control dampers shall be opposed blade or parallel blade type and two position (open/close) dampers shall be parallel blade type.
- 2.13.1.3 All blade linkage hardware shall have corrosion-resistant finish (stainless steel) and be readily accessible for maintenance.
- 2.13.2 Standard Modulating and Two-Position Dampers:
- 2.13.2.1 Manufacturers and acceptable model numbers:
- Johnson Controls (VD-1250 or better)
Ruskin (CD50 or better)
Tamco (1500 or better)
Greenheck (VCD-43 or better)
- 2.13.2.2 **[Aluminum/stainless]** steel damper frame shall not be less than .125" in wall thickness. **[Aluminum/stainless]** steel frame shall be clear anodized to a minimum thickness of 0.7mil (18 microns) deep. Where screws are used, they must be 316 stainless steel.
- 2.13.2.3 Extruded **[Aluminum/stainless]** steel blades shall be clear anodized to a minimum thickness in accordance with 215R1. **[Aluminum/stainless]** steel blade pivot rods shall be clear anodized. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.
- 2.13.2.4 Dampers shall have a maximum leakage of 8 CFM/sqft at 4" WG differential static pressure. Leakage shall meet AMCA Class 1 Standards.
- 2.13.2.5 Blade and frame seals shall be of extruded silicone. Seals are to be secured in an integral slot within the blade extrusions and shall be mechanically fastened to each blade.
- 2.13.2.6 Linkage hardware to be installed in the frame side and out of the air stream. All aluminum linkage hardware parts shall be clear anodized. All non-aluminum linkage hardware parts shall be 300 series stainless steel. Adjustable hexagon drive rod, U-bolt fastener and retaining nuts are to be 300 series stainless steel.
- 2.13.2.7 Axles: Minimum shall be stainless steel or plated steel.
- 2.13.2.8 Dampers are to be designed for operation in temperatures ranging between -72°F (-58°C) and 212°F (100°C).
- 2.13.2.9 Dampers shall be available with either opposed blade action or parallel blade action.
- 2.13.2.10 Dampers shall be made to size required without blanking off free area.

- 2.13.2.11 Dampers shall be available in two mounting types: i.e., "Installed in Duct" or "Flanged to Duct".
- 2.13.2.12 All performance data shall be documented using AMCA 500-D Laboratory Methods for Testing Dampers for Ratings and be AMCA licensed as a Class 1A Damper.
- 2.14 Damper and Valve Actuators:
- 2.14.1 Damper and valve actuators for major equipment [**Central Utility Plant, AHU's, Lab Exhaust Fan Systems, etc**] located in mechanical rooms shall be [**pneumatic type/electric type**]. Actuators for all remote terminal devices [**VAV Terminal Units, Reheat Coils, FCU's, Heat Pumps, etc...**] located in spaces outside of mechanical rooms shall be electric type.
- 2.14.2 Each actuator shall be full-proportioning or two-position type as required or specified, and shall be provided with spring-return for fail open or fail closed position for fire, freeze, occupant safety, equipment protection, moisture, heating or cooling protection on power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail closed.
- 2.14.3 Pneumatic Diaphragm with Spring Return: Actuators shall be same manufacturer as valve body and shall be selected to match maximum diaphragm air pressure, fail position, stroke, shutoff pressure, temperature, torque, etc., required for intended service. Unless otherwise scheduled, diaphragm air pressure shall be enough to provide 100% valve shutoff at least equal to pump shutoff head or 125% of rated flow head for water systems, or full rated pressure for steam systems. Select spring ranges to match intended service. If valves or dampers are sequenced, spring ranges shall not overlap.
- 2.14.4 Pneumatic Piston Actuator: Provide dual action piston actuators for large torque applications. Actuators shall be sliding piston type with appropriate linkage and mounting hardware. Provide units suitable for 60 to 100 psig compressed air operation, self-draining body, position indicator, and spring return if fail position required. Body shall be aluminum or fiberglass with aluminum piston, BUNA-N or PTFE piston seals, and open/close travel stops.
- 2.14.5 Pilot Positioners (Pneumatic Actuators Only):
- 2.14.5.1 Provide pilot positioners with mechanical feedback of actual actuator position. Pilot positioners may use 3-15 psi pneumatic input signal with a full range 3-15 psi pneumatic output. Input ranges and gain factors shall be field adjustable.
- 2.14.6 Analog Electronic:
- 2.14.6.1 Actuators shall be electric motor/gear drives which respond proportionally to analog voltage or current input. Stroke time for major equipment shall be [**90 seconds**] or less for 90° rotation. Stroke time for terminal equipment shall be compatible with its associated local controller, but no more than [**6 minutes**].
- 2.14.6.2 Provide spring return feature for fail open or closed positions as required by control sequence and for critical application devices.

- 2.14.6.3 Reheat terminal units - Utilize factory assembled ball valve with horizontal mount; non-spring return proportional actuator (0-10 Vdc, 0-5Vdc, or 4-20ma). Electric actuator installed on ball valves shall have a separate and distinct operating handle used to position the valve into any desired position once power is removed or a valve failure occurs. Similar to Belimo B2 CCV Series valve/actuators
- 2.14.6.4 Actuators for terminal heating/cooling equipment shall be configured to fail to last position.
- 2.14.6.5 Provide standard cable from actuator to controller unit.
- 2.14.7 Discrete Two-Position Electric:
 - 2.14.7.1 Actuators shall be hydraulic or electric motor/gear drives for two-position control. Stroke time shall be [**90 seconds**] or less for 90° rotation.
 - 2.14.7.2 Provide spring return feature for fail open or closed positions as required by control sequence.
 - 2.14.7.3 Provide adjustable end switches as required by control sequence.
- 2.15 General Instrumentation:
 - 2.15.1 Pressure Gauges:
 - 2.15.1.1 Air pressure indicating gauges to be at least 1-1/2" diameter. Gauge faces to be marked with range of unit being controlled.
 - 2.15.1.2 Pressure gauges used for panel-mounted indicators shall be marked in appropriate units and with appropriate range of values. Panel mounted indicators shall be minimum 4-1/2" in diameter and have accuracy of 1% of scale range.
 - 2.15.2 Analog Electronic Instrument Indicators:
 - 2.15.2.1 Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output may be analog needle type or digital with 1/2" high LED or backlit LCD displays.
 - 2.15.2.2 Electronic indicators shall be marked in appropriate units (Degrees, psi, %RH, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.
- 2.16 Discrete Electric Instrumentation:
 - 2.16.1 General:
 - 2.16.1.1 Electrical devices, switches, and relays shall be UL listed and of type meeting current and voltage characteristics of the project.
 - 2.16.1.2 Outdoor unit enclosures shall be NEMA 4 with concealed adjustment.

- 2.16.1.3 Ratings of normally open and closed contacts shall be adequate for applied load (Minimum 5 amps at 240 volts).
- 2.16.1.4 Accuracy of devices shall be $\pm 1\%$ of scale with adjustable offset unless otherwise specified.
- 2.16.2 Temperature Switches (Electric Thermostats):
 - 2.16.2.1 Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.
 - 2.16.2.2 Low voltage type to have heat anticipation.
 - 2.16.2.3 Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.
 - 2.16.2.4 Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.
 - 2.16.2.5 Unless otherwise stated, space thermostat covers shall be factory standard cover.
- 2.16.3 Temperature Low Limit Switches:
 - 2.16.3.1 Electric 2-position 4 wire, 2 circuit temperature sensing element with manual reset. Controls shall be capable of opening circuit if any one-foot length of sensing element is subject to temperature below established setpoint.
 - 2.16.3.2 Sensing element shall not be less than one lineal foot per square foot of coil surface area. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.
 - 2.16.3.3 Low Limit switches shall be hardwired into safety circuit of motor control device. Additional contact shall be used for BAS feedback.
 - 2.16.3.4 Location of installed device – must be accessible from outside of unit, must be protected from the water and must be mounted no more than 60” AFF. Provide remote (hardwired) reset switch when conditions require device to be mounted above 60” AFF.
 - 2.16.3.5 Provide multiple devices for large AHUs where required to ensure complete coverage.
- 2.16.4 Relays:
 - 2.16.4.1 Equal to IDEC type or RIB series. Coil shall match control circuit characteristics. All relays shall include LED indication of status.
 - 2.16.4.2 Where HOA capability is required (i.e. AAC), relays must include an integral HOA function with override feedback.
 - 2.16.4.3 Provide DIN rail mountable (Snap type) mounting sockets.
- 2.16.5 Pressure Switches:

- 2.16.5.1 Adjustable set point, differential pressure type. Select switches for accuracy, ranges (20 to 80% of operating range) and dead-band to match process conditions, electrical requirements and to implement intended functions.
- 2.16.5.2 Pressure differential switches for air systems shall have pressure rating of at least 10" WG.
- 2.16.5.3 Pressure indicating differential switches for air systems shall be equal to Cleveland AFS series photohelic gauge.
- 2.16.5.4 Pressure differential switches for water systems shall be rated for 150 psig unless otherwise noted. Chilled water pressure differential switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches to have 3-valve manifold for servicing. Taps for TAB shall be provided.

Maximum Temperature Rating: 300°F
 Repeatability: ± 1%

2.16.6 Target Type (Paddle) Flow Switches:

- 2.16.6.1 Adjustable set point, paddle type. Select switches for accuracy and ranges to match process conditions, electrical requirements, and to implement intended functions.
- 2.16.6.2 Air sensing switches shall be for duct mounting, top, side, or bottom. Mounting in vertical duct with downward flow is not allowed.
- 2.16.6.3 Water-sensing switches shall include NPT fittings suitable for mounting on piping. Switches shall be rated for 150 psi. Chilled water switches shall be rated for 300 psi.

Maximum Temperature: 200°F
 Repeatability: ±1%
 Pressure Rating: 300 psi for chilled water
 150 psi for other applications

2.16.7 E-P Switches (Solenoid Valves):

- 2.16.7.1 Manufacturers: Asco, Johnson Controls, Siemens Industry.
- 2.16.7.2 E-P switches shall provide control air for operation of fan isolation dampers, smoke or smoke/fire dampers, or other On/Off actuators. Line voltage actuators shall be Class "H" (high temperature) and listed by UL or CSA.

Valve Body: Brass or bronze
 Valve Type: 2-way or 3-way
 Operating Voltage: 24 VDC, 24 VAC, 120 VAC or as specified
 Operating Temperature: 32 to 104°F
 Operating Pressure: Greater than maximum supply pressure
 Pipe Size: 1/4" NPT
 Enclosure Rating: NEMA 4

- Conduit Connection: 3/4"
- 2.16.8 Position Switches (End Switches)
- 2.16.8.1 Rotary switches shall consist of switch mounted on a 1/2" damper crank arm (Similar to Kele & Associates TS-475).
- 2.16.8.2 Door position switches shall be magnetic proximity type.
- 2.16.9 Current Switches:
- 2.16.9.1 Induction type sensor clamped over a single phase of AC electrical power conductor shall be solid-state sensor with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.
- 2.16.9.2 VFD and NON-VFD Applications (Similar to Hawkeye Model 904,934).
- 2.16.9.2.1 The sensor shall be capable of detecting motor belt or coupling loss when mounted on the load side of variable frequency drives
- 2.16.9.2.2 The current sensor shall be factory programmed to detect motor undercurrent situations (belt or coupling loss) on variable or constant volume loads, no calibration required.
- 2.16.9.2.3 The current sensor shall store the motor current operating parameters in non-volatile memory.
- 2.16.9.2.4 The current sensor shall have a push button reset to clear the memory if the operating parameters change or the sensor is moved to a different load.
- 2.16.9.2.5 Transition current: 75 mA at 1 A setpoint
2.5 A at 10 A setpoint
- 2.16.9.2.6 Hysteresis: 0.015 A at 1 A setpoint
0.20 A at 10 A setpoint
- 2.16.9.2.7 Response Time: less than 0.5 seconds
- 2.17 Analog Electronic Instrumentation:
- 2.17.1 Differential Pressure Transmitter:
- 2.17.1.1 Manufacturers: Ashcroft, BAPI, Setra, Veris (w/LCD Display).
- 2.17.1.2 Pressure sensor and integral 4-20 mA VDC transmitter. Select instrument for intended usage (differential pressure, gauge pressure, level, etc.), range, maximum pressure/temperature. Sensor shall be capacitance or strain gauge type. Enclosure to be NEMA 4. Compound filter differential pressure sensor range to be +/- 2.5" w.c.
- 2.17.1.3 Differential pressure transmitters shall have 3-valve manifold for servicing.

- 2.17.1.4 Differential pressure sensing lines shall include a dedicated test port on both the high and low side sensing lines.
- 2.17.1.5 Diaphragm Material: Stainless Steel or Hastelloy
- 2.17.1.6 Process Connection: 1/2" NPT Stainless Steel
- 2.17.1.7 Power Supply Voltage: 13 - 35 VDC unregulated
- 2.17.1.8 Over Pressure: 1000 psig or 2 times maximum operating pressure whichever is greater.
- 2.17.1.9 Accuracy: $\pm 0.25\%$ of calibrated span, including effects of linearity
- 2.17.1.10 Drift: $\pm 0.1\%$ of upper limit for 6 months.
- 2.17.1.11 Power Supply Effect: Less than 0.01% of output span per volt.
- 2.17.1.12 Static Pressure Effect: Zero Error: $\pm 0.1\%$ of upper range limit per 1000 psi.
- 2.17.1.13 Span Error: $\pm 0.075\%$ of reading per 1000 psi.
- 2.17.1.14 Temperature Effect: $\pm (0.025\%$ upper range limit plus 0.125% span) per 50°F .
- 2.17.1.15 Zero control shall be continuously adjustable between $\pm 50\%$ of upper range limit. Total calibrated span and zero adjustment cannot exceed upper range limit. Zero span shall be independently field-adjustable with no interaction.
- 2.17.2 Wall Mounted Space Sensors:
- 2.17.2.1 Sensors shall be platinum or nickel RTD type, with the following minimum performance:
- 2.17.2.1.1 Temperature Coefficient of Resistivity (TCR): .00385 ohm/ohm/ $^{\circ}\text{C}$
- 2.17.2.1.2 Accuracy: $\pm 0.1\%$ at 32°F (Class B)
- 2.17.2.1.3 Conformance: DIN-IEC 751
- 2.17.2.1.4 Operating Range: -50 to 500°F
0 to 99% RH
- 2.17.2.2 Thermistors will be acceptable in lieu of platinum or nickel RTD provided thermistor carries 5 year guarantee that device will maintain its accuracy within tolerance of $\pm 0.36^{\circ}\text{F}$ between 32°F and 150°F , and 0.5°F between -20°F and 212°F .
- 2.17.2.3 Unless otherwise stated, space sensor covers shall be factory standard cover
- 2.17.3 Room Thermostats:

- 2.17.3.1 Setpoint range shall be resettable only from remote BAS or from any server/client PC. Temperature sensors shall be compatible with the associated controlled devices (e.g. DDC air terminal controller). Mounting box shall be recessed type unless otherwise indicated, or required by the building construction materials.
- 2.17.3.2 Room Temperature Sensors shall incorporate a thermistor/RTD element and an integral portable operator terminal plug-in port.
- 2.17.3.3 Temporary override push-button/timers shall be installed at all locations.
- 2.17.3.4 Provide warmer/cooler setpoint adjustment. Minimum and maximum adjustable range shall be set through the BAS only.
- 2.17.3.5 Unless otherwise stated, Room Thermostat covers shall be factory standard cover.
- 2.17.3.6 Unless otherwise stated, room thermostat shall not include a local LCD display.
- 2.17.4 Duct Mounted Probe Temperature Sensors:
- 2.17.4.1 Nickel or platinum RTD type, with the following minimum performance:
- | | |
|--------------------------|----------------------------|
| Temperature Coefficient: | .00385 ohm/ohm/°C |
| Accuracy: | +/- 0.1% at 32°F (Class B) |
| Conformance: | DIN-IEC 751 |
| Operating Range: | 0 to 150°F |
| | 0 to 99% RH |
- 2.17.4.2 Thermistors or nickel RTD will be acceptable in lieu of platinum RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of $\pm 0.36^{\circ}\text{F}$ between 32°F and 150°F, and 0.5°F between -20°F and 212°F.
- 2.17.4.3 Furnish sensors as shown on drawings or required for proper operation.
- 2.17.5 Wet Insertion Temperature Sensors:
- 2.17.5.1 Nickel or platinum RTD type, with the following minimum performance:
- | | |
|--------------------------|----------------------------|
| Temperature Coefficient: | .00385 ohm/ohm/°C |
| Accuracy: | +/- 0.1% at 32°F (Class B) |
| Conformance: | DIN-IEC 751 |
| Operating Range: | -50 to 170°F |
| | 0 to 99% RH |
- 2.17.5.2 Thermistors or nickel RTD will be acceptable in lieu of platinum RTD provided thermistor carries 5 year guarantee that the device will maintain its accuracy within a tolerance of $\pm 0.36^{\circ}\text{F}$ between 32°F and 150°F, and 0.5°F between -20°F and 212°F.
- 2.17.5.3 Furnish sensors and wells as shown on drawings or required for proper operation.
- 2.17.5.4 Coordinate the installation of sensor wells.

- 2.17.5.4.1 Wells mounted in pipe 3" and larger may be installed in horizontal or vertical lines provided element is always in flow (for condensate and other gravity return lines, install in bottom of pipe).
- 2.17.5.4.2 Wells mounted in pipe 2-1/2" and smaller shall be installed at a 90° pipe junction consisting of tee fitting (2" minimum size) and appropriate reducing fittings.
- 2.17.5.4.3 Wells shall be brass or stainless steel and include thermal grease to ensure adequate heat transfer.
- 2.17.5.5 Install sensor well pointed upstream in tee.
- 2.17.6 Duct Mounted Averaging Temperature Sensors: (Not applicable to terminal units).
- 2.17.6.1 Rigid averaging temperature probes are unacceptable.
- 2.17.6.2 Nickel or platinum RTD type, with the following minimum performance
- | | |
|--------------------------|---------------------------|
| Temperature Coefficient: | .00385 ohm/ohm/°C |
| Accuracy: | ± 1.0% at 32°F (Class B) |
| Conformance: | DIN-IEC 751 |
| Operating Range: | -50 to 170°F, 0 to 99% RH |
- 2.17.6.3 Provide non-metal support system to ensure correct minimum bend radius.
- 2.17.7 Dew Point Temperature Transmitter:
- 2.17.7.1 Manufacturers: General Eastern, Hy-Cal, Vaisala.
- 2.17.7.2 Chilled mirror type primary dew point temperature measurement using platinum RTD, 4 wire, 100 ohm temperature sensing element with 4-20 mA transmitter.
- | | |
|----------------|--|
| Accuracy: | ± 1°F |
| Repeatability: | ± 0.1°F |
| Hysteresis: | None |
| Sensor Range: | -10°F to +140°F dew point
32°F to 140°F ambient |
- 2.17.7.3 Unit shall be selected for proper application (wall or duct mounted).
- 2.17.8 Critical Area: Space Humidity Sensors/Transmitters:
- 2.17.8.1 Manufacturers: General Eastern, TCS, Hy-Cal, Rtonic or Vaisala.
- 2.17.8.2 Space humidity sensors shall be wall mount type with cover to match room thermostats and/or temperature sensors.
- 2.17.8.3 Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.

- | | |
|----------------------|---|
| Accuracy: | ± 2% RH at 25°C over 20-95% RH including hysteresis, linearity and repeatability. |
| Temperature Effect: | Less than 0.06% per °F. |
| Sensitivity: | 0.1% RH. |
| Repeatability: | 0.5% RH. |
| Hysteresis: | Less than 1%. |
| Long Term Stability: | Less than 1% RH drift per year. |
| Adjustment: | ± 20% RH zero, non-interactive.
± 10% RH span, non-interactive. |
| Operating Range: | 0-99% RH, non-condensing, sensor.
0-95% RH, non-condensing, electronics. |
| Output: | 4-20 mA, 0-10Vdc, 0-100% linear, proportional |
| Power: | 12-36 VDC. |
- 2.17.8.4 Space humidity sensor covers shall be factory standard cover unless otherwise stated.
- 2.17.9 Critical Area: Duct Mounted Humidity Sensors/Transmitters:
- 2.17.9.1 Manufacturers: General Eastern, TCS, Hy-Cal, Rotonix or Vaisala.
- 2.17.9.2 Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
- | | |
|----------------------|---|
| Accuracy: | ± 2% RH at 25°C over 20-95% RH including hysteresis, linearity and repeatability. |
| Temperature Effect: | Less than 0.06% per °F. |
| Sensitivity: | 0.1% RH. |
| Repeatability: | 0.5% RH. |
| Hysteresis: | Less than 1%. |
| Long Term Stability: | Less than 1% drift per year. |
| Adjustment: | 20% RH zero, non-interactive.
10% RH span, non-interactive. |
| Operating Range: | 0-99% RH, non-condensing, sensor.
0-95% RH, non-condensing, electronics. |
| Output: | 4-20 mA, 0-10Vdc, 0-100% linear, proportional |
| Power: | 12-36 VDC. |
- 2.17.10 Non Critical Area: Space Humidity Sensors/Transmitters:
- 2.17.10.1 Manufacturers: Siemens, Johnson Controls, BAPI, Veris or approved equal.
- 2.17.10.2 Space humidity sensors shall be wall mount type with cover to match room thermostats and/or temperature sensors.
- 2.17.10.3 Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
- | | |
|-------------------|---------------------------------------|
| Accuracy: | ± 3% RH at (50°F-95°F) over 20-80% RH |
| Calibrated Range: | 10-90% RH |

- | | |
|----------------------|---|
| Hysteresis: | n.n% |
| Long Term Stability: | +/- n% RH drift per year |
| Operating Range: | 32 to 131°F, 10 to 95% RH non-condensing |
| Output: | 4-20 mA, 0-10Vdc, 0-100% linear, proportional |
| Power: | 12-36 VDC/VAC |
- 2.17.10.4 Space humidity sensor covers shall be factory standard cover unless otherwise stated.
- 2.17.11 Non Critical Area: Space Humidity Sensors/Transmitters:
- 2.17.11.1 Manufacturers: Siemens, Johnson Controls, BAPI, Veris or approved equal.
- 2.17.11.2 Probe type, temperature compensated, resistive bulk polymer or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.
- | | |
|----------------------|---|
| Accuracy: | ± 3% RH at (50°F-95°F) over 20-80% RH |
| Calibrated Range: | 10-90% RH |
| Hysteresis: | n.n% |
| Long Term Stability: | +/- n% RH drift per year |
| Operating Range: | 32 to 131°F, 10 to 95% RH non-condensing |
| Output: | 4-20 mA, 0-10Vdc, 0-100% linear, proportional |
| Power: | 12-36 VDC/VAC |
- 2.17.12 Air Flow Sensors/Transmitters:
- 2.17.12.1 Manufacturers: Tek-Air or Ebtron Gold Series with the following characteristics:
- 2.17.12.1.1 Velocity measured by each sensor shall be linearized, summed, averaged, and converted to 4-20 mA output signal proportional to air flow rate (CFM) by transmitter electronics.
- 2.17.12.1.2 Measured value converted to airflow (CFM) shall have accuracy within 2% rate ± 0.1% full scale throughout velocity range and temperature and humidity change of 40 to 130°F, and 10-95% RH (non-condensing).
- 2.17.12.1.3 Transmitter shall be provided as part of air flow sensor, and shall include integral diagnostics with on-line zeroing and sensor operation verification.
- 2.17.12.2 Manufacturer shall provide all cabling required to connect probe assemblies and transmitter electronics. Transmitter and/or systems, which require periodic calibration to maintain accuracy specified shall not be acceptable.
- 2.17.12.3 Provide a local display to indicate calculated cfm.
- 2.17.13 P-E Transducers (Pressure Transmitters):
- 2.17.13.1 Manufacturers: Ashcroft, Mamac, Setra, BAPI or Veris
- 2.17.13.2 Units shall have the following characteristics:
- | | |
|--------|-----------------------------|
| Input: | Pressure 0-15 psig, minimum |
|--------|-----------------------------|

- | | |
|-----------------------|-------------------------------------|
| Output Signal: | 4-20 mA, 0-5 VDC, 1-5 VDC, 1-10 VDC |
| Accuracy: | 1% of span |
| Operating Temperature | 32 to 125°F |
| Power Requirements: | 24 VDC (10-30 VDC) |
- 2.17.14 Provide local LCD display.
- 2.17.15 Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:
- 2.17.15.1 Manufacturers: Ashcroft, BAPI, Mamac, Setra, Veris.
- 2.17.15.2 Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
- 2.17.15.3 Unit shall be capable of transmitting linear 4 to 20 mA DC output signal proportional to the differential (total minus static or static minus ambient) pressure input signals with the following minimum performance and application criteria:
- | | |
|----------------|--|
| Span: | Not greater than twice duct static or velocity pressure at maximum flow rate, nor more than 16 times velocity pressure at minimum flow rate. |
| Accuracy: | ± 1.0% of span or 1.0% of full scale |
| Dead Band: | Less than 0.5% of output |
| Hysteresis: | Within 0.5% of span or within 0.5% of full scale |
| Linearity: | Within 1.0% of span or within 0.5% of full scale |
| Repeatability: | Within 0.5% of output |
| Response: | Less than 1 second for full span input |
- 2.17.15.4 Return and exhaust air system static pressure transducers/transmitters shall be furnished with protective integral air filters on pressure sensing lines from the static pressure sensing stations, and static air probes to prevent migration of moisture or particulate matter into transducers. Supply air system sensors do not require integral air filters.
- 2.17.15.5 Provide local LCD display.
- 2.17.16 Building and Space Pressure Differential Transmitter:
- 2.17.16.1 Manufacturers: BAPI, Mamac, Setra, Veris.
- | | |
|--------------------------|--|
| Accuracy: | ± 1.5% full scale, 0.5% reading |
| Repeatability: | ± 0.2% of full scale |
| Probe Temperature Range: | -40°C to 121°C (-40°F to 250°F) |
| Pressure Range: | 150 psig, max |
| Response Time: | 400 msec. to within 63% of final value |
| Output Signal: | 4-20 mA |
- Sensor location to be on record drawings.
- 2.17.16.2 Provide local LCD display.

2.17.17 Electric to Pressure Transducers:

2.17.17.1 Manufacturers: Veris EP 3000 series

2.17.17.2 Provide pressure transducers integral to DDC panels or separate components to convert digital analog signal to variable pneumatic air pressure signal. Units to have following characteristics:

Input	4-20 mA or 0-5 VDC
Linearity	1% of span
Hysteresis	0.75% of span
Maximum air consumption	0.008 scfm @ 20 psi

Incorporate a manual override switch and, in the manual mode, the pressure shall be increased or decreased.

2.17.17.3 Carbon Dioxide Sensor: (Space or Duct Mounted)

2.17.17.4 Manufacturer: Valtronics Model 2089, Veris CXD, Siemens or approved equal.

2.17.17.5 Provide non-Dispersive Infra Red (NDIR) carbon dioxide sensor suitable for room mounting. 4-20 ma output signal corresponding to input CO2 concentration.

Input	4-20 mA
Range	0-2000 PPM
Accuracy	+/- 3% of full scale
Repeatability	.1% of full scale
Calibration frequency	No less than every 3 years

2.18 Energy Metering:

2.18.1 General: The sensor /transducer shall be appropriately selected to most closely match the expected sensing range. If, upon startup and balancing, a sensor/transducer is operating below 20% or above 80% of its sensing range, the sensor/transducer shall be replaced at no additional cost with an appropriate range such that the measured value (operating at normal conditions) is between 30% and 70% of the range.

2.18.2 Btu Energy Meter:

2.18.2.1 The entire energy metering system shall be built and calibrated by a single manufacturer, ONICON Incorporated, and shall consist of a flow meter, two temperature sensors, a Btu [**chilled water/hot water**] calculator, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST* traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer's two year warranty.

2.18.2.2 Btu Meter: Provide an ONICON System-10 Btu Meter. The Btu meter shall provide the following points both at the integral LCD and as outputs to the building control system: Energy Total [**ktonhr/MBtu**], Energy Rate [**tons or MBtu/hr**], Flow Rate (GPM), Flow Total (KGal) Supply Temperature (DEGF) and Return Temperature (DEGF). Output signals shall be serial network protocol conforming to Siemens-P1. Each Btu meter shall be factory

- programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).
- 2.18.2.3 Temperature sensors: Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application. The calculated differential temperature used the energy calculation shall be accurate to within ± 0.15 (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).
- 2.18.2.4 Flow Meter: Refer to the following flow meter sections for specific flow meter requirements. The flow meter shall be installed either in the supply or return pipe of the system to be measured following the manufacturer's instructions with particular attention to upstream and downstream straight pipe runs.
- 2.18.3 [Chilled Water // and // Heating Hot Water Flow Meter] [USE THIS WHEN PIPE IS SMALLER THAN 3"]**
- 2.18.3.1 Provide an ONICON F-3100 Series Inline Electromagnetic Flow Meter complete with integral or remote Series 3900 Converter. The converter shall include a backlit graphic display and keypad. The flow meter shall be installed either in the supply or return pipe of the system to be measured following the manufacturer's instructions.
- 2.18.3.1.1 The flow meter size shall be selected based on the minimum and maximum flow range for the application.
- 2.18.3.1.2 Connections to the piping shall be ANSI class 150 flanges (ANSI Class 300 where required).
- 2.18.3.1.3 The installing contractor is responsible for providing suitable mating flanges and any required reducer/expander.
- 2.18.3.1.4 The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene for low temperature service, PTFE for hot water service.
- 2.18.3.1.5 Each flow meter shall be individually wet-calibrated and accurate to within $\pm 0.2\%$ of reading from 3 to 33 feet per second velocity. A certificate of calibration shall be provided with each flow meter.
- 2.18.3.1.6 Output signals shall be 4-20 mA and programmable pulse.
- 2.18.3.1.7 The flow meter shall be capable of measuring bi-directional flow.
- 2.18.3.1.8 For installations in non-metallic pipe, an internal grounding electrode shall be provided which eliminates the need for external grounding rings.
- 2.18.3.1.9 Each flow meter shall be factory programmed for its specific application, and shall be reprogrammable using the integral keypad on the converter (no special interface device or computer required).
- 2.18.3.2 Flow Display: Provide a D-1200 Series Display Module for local or remote indication of flow rate and/or total.

- 2.18.4 **[Chilled Water // and // Heating Hot Water Flow Meter] [USE THIS WHEN PIPE SIZE IS 3" OR LARGER]**
- 2.18.4.1 Provide an ONICON Model F-3500 Insertion Electromagnetic Flow Meter, complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.
- 2.18.4.2 The flow meter shall be hand-insertable up to 400 psi.
- 2.18.4.3 Materials of construction for wetted metal components shall be 316 SS.
- 2.18.4.4 The flow meter shall average velocity readings from two sets of diametrically opposed electrodes.
- 2.18.4.5 Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to National Institute of Standards and Technology (NIST). A certificate of calibration shall be provided with each flow meter.
- 2.18.4.6 Accuracy shall be within $\pm 1\%$ of rate from 2-20 ft/s.
- 2.18.4.7 Output signals shall be completely isolated and shall consist of the following:
- 2.18.4.7.1 High resolution frequency output for use with peripheral devices such as an ONICON display module or Btu meter
- 2.18.4.7.2 Analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, and provide scalable dry contact output for totalization.
- 2.18.5 Flow Display: Provide a D-1200 Series Display Module for local or remote indication of flow rate and/or total.
- 2.18.6 Steam Flow Meter
- 2.18.6.1 Furnish and install an Yokogawa Model YF100 Vortex flow meter with remote converter capable of providing a 4-20 mA DC signal proportional to flow rate. Accuracy of meter shall be $\pm 0.8\%$ of reading with a repeatability of 0.2%.
- 2.18.6.2 The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer's recommendations. Provide a flow straightener, if required to meet the manufacturer's minimum upstream straight pipe run requirement. Provide lateral and horizontal supports as required to minimize vibration at the meter location.
- 2.18.6.3 Each flow meter shall be individually calibrated at five points from 0-250 ft/s against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for each meter.
- 2.18.6.4 The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

- 2.18.6.5 Construction: Meter shall have no moving parts. Body shall be ASTM A296 Grade CF8M (ANSI 316) Hastelloy C. Shedder bar shall be duplex stainless steel Hastelloy C. Gasket shall be stainless steel with Teflon coating. Housing and cover shall be aluminum alloy.
- 2.18.6.6 Converter: Furnish remote mounted converter in NEMA 4X enclosure. Provide signal cable to connect meter and converter.
- 2.18.6.7 Installation: Mount meter with 20 upstream and 5 downstream diameters of straight pipe. Flow meter may be mounted vertically, horizontally or at any other angle.
- 2.18.7 Natural Gas Meter
- 2.18.7.1 Furnish and install an F-5100 Series Thermal Mass Flow Meter complete with integral density compensation to provide direct mass flow output. The flow meter shall calculate mass flow rate (Cfh) and mass flow consumption (therms) directly and shall not require additional pressure or temperature compensation.
- 2.18.7.2 The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer's recommendations. Provide lateral and horizontal supports as required to minimize vibration at the meter location.
- 2.18.7.3 Each flow meter shall be individually calibrated at five points against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for each meter.
- 2.18.7.4 The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.
- 2.18.7.5 Mass flow accuracy shall be within $\pm 2.0\%$ of actual reading over the range of the meter, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation.
- 2.18.7.6 The meter shall be provided with wetted metal components 316 stainless steel as required to meet system requirements. The maximum operating temperature shall be 200° F.
- 2.18.7.7 The flow meter body shall be constructed of 300 series stainless steel and include a weather-tight NEMA-4 aluminum electronics enclosure.
- 2.18.7.8 The meter shall display mass flow rate with an integral LCD display and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.
- 2.18.7.9 The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the BAS. In addition, an integral pulse output for mass flow totalization shall be provided. All outputs shall be linear with mass flow rate.
- 2.18.7.10 Remote Serial Network Interface Module: Provide an ONICON D-100 Network Interface. The network interface shall transmit Mass Flow Rate [Cfh] and Total Mass data [therms] via a serial network conforming to one of the following protocols: Siemens P1.
- 2.18.8 Domestic Water Flow Meters: Provide for Domestic Water (building main, make up water).

- 2.18.8.1 Inline Flow Meter with pulser:
 - 2.18.8.1.1 Construction: Provide brass sensor housing and electronics enclosure for indoor use. Provide optional outdoor enclosure for meters exposed to the environment. Rotors shall be low mass, non-metallic and run on tungsten carbide shafts.
 - 2.18.8.1.2 Application: Maximum operating pressure of 250 psi and operating temperature of 180°F.
 - 2.18.8.1.3 Electronics: Provide the following output signals: dry contact pulser.
 - 2.18.8.1.4 Approved Manufacturers: ASCO. No other manufacturers are acceptable.

3 EXECUTION

3.1 Software:

- 3.1.1 Coordinate graphics and points for consistency with existing campus system. Contractor shall be responsible for data base clean-up when a project is renovated. The graphic database, user view data base and software will be modified to reflect the final project.
- 3.1.2 Continuously archive all data in standard database platform. Including but not limited to:
 - 3.1.2.1 I/O points
 - 3.1.2.2 Software points such as:
 - 3.1.2.2.1 Alarm limits
 - 3.1.2.2.2 Setpoints
 - 3.1.2.2.3 Parameters
 - 3.1.2.3 Schedules
 - 3.1.2.4 Alarm messages
 - 3.1.2.5 Reports
 - 3.1.2.6 Trends/History
- 3.1.3 Provide BAS Reports including:
 - 3.1.3.1 Alarm Summary
 - 3.1.3.2 Schedules
 - 3.1.3.3 Control Loop Performance
 - 3.1.3.4 Equipment specific energy performance calculations such as Energy Recovery Devices.
 - 3.1.3.5 Measurement and verification reports consistent with the requirements of the M+V plan developed by a separate 3rd party agent.
- 3.1.4 The Contractor shall implement long term trending for all physical input and output points and all set-points. The initial trend interval settings shall be set to 15 minutes. In addition, the Contractor shall increase the resolution of all control loop trending to every 5 minutes

- during the testing/acceptance phase (minimum of 2 weeks). Control loop trending shall include controlled variable, setpoint, and output from actuated device. Coordinate all trending requirements with [**Commissioning Agent/Engineer**].
- 3.1.5 Alarming:
- 3.1.5.1 The Contractor shall create enhanced alarm programs for all system points. These points shall be programmed for appropriate seasonal high or low alarm limits. Enhanced alarm programs shall prevent abnormal alarms from occurring when the associated system has been deactivated. For example: air handler mixed air, preheat, cooling, humidity, and static pressure control points, building chilled water, heating water system control points, etc. Alarms shall occur only while systems are active and being supplied with chilled/hot water or steam at normal operating temperatures and pressures. Alarm destinations, alarm messages, and point graphic assignments shall be included so that alarms are indicated and printed at a pre-defined Owner reporting device and recorded on a transaction log. Alarms shall have accurate descriptions and response instructions, so that alarms may be quickly associated with appropriate graphic display.
- 3.1.5.2 The Contractor shall define the specific system reactions for each point. Alarms shall be enhanced and prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. The Contractor shall initially define all point priority levels for handling of all system alarms. Users shall have the ability to manually inhibit alarm reporting for each point.
- 3.1.5.3 Alarm reports and messages shall be directed to a user-defined list of operator devices or PCs based on time (after hour destinations) and/or based on priority.
- 3.1.5.4 In addition to the point=s descriptor and the time and date, the Contractor shall create, print, display and store an alarm message for each point to more fully describe the alarm condition or to direct operator response. Alarm events may be configured to send an alarm message to a specified client e-mail address, cellular phone number via SMS text messaging.
- 3.1.6 Graphic Displays:
- 3.1.6.1 Provide a color graphic system flow diagram display for each system with all points as indicated on the point list.
- 3.1.6.2 Provide graphics for each floor plans of the building as a minimum. Coordinate with the Architect/Engineer (A/E). Size graphics to allow the operator to read room numbers and descriptions. Incorporate the capability to navigate section to section as required to view entire floor and to navigate floor to floor.
- 3.1.6.3 Color shall be used to indicate normal and alarm conditions within all spaces. Color or common border lines shall be used to link HVAC equipment with zone(s) served.
- 3.1.6.4 User shall be able to access the various system schematics and floor plans via a graphical penetration scheme and/or menu selection.
- 3.1.6.4.1 User shall be able to penetrate from floor plan to associated HVAC system text based display.

- 3.1.6.5 Create enhanced alarm programs for all system points. These points shall be programmed for appropriate seasonal high or low alarm limits.
- 3.1.6.6 Refer to the following graphics guideline section and Graphic Standards - Appendix B for additional examples and samples.
- 3.2 Graphical Standard Guidelines:
- 3.2.1 Legend: The legend screen will show the user the color coding intent of the graphics and instructions to help the operator with various viewing commands. There will be links to the site map and previous screen in the top left corner. Bottom of the page will contain the following outdoor readings: Dry bulb, relative humidity and wet bulb and include time and date information.
- 3.2.2 Site Map: After initiating the building automation graphics the first screen to appear will be the FSU Site Map. The site map will display a portion of the FSU map with non-integrated buildings colored gray. The FSU buildings connected to the BAS will be colored with one of two colors – red or green. The green colored buildings will show the user that there are no alarms active in the building, while red color will indicate that one or more of building systems are in an alarm state. The user will have the ability to adjust building alarm activation trigger based on alarm priority. The buildings in alarm shall flash red continuously until alarm is acknowledged and remain solid as long as the alarm condition remains active.
- 3.2.3 In order to see the name of each building the user will be able to hover the cursor over the building icon, this feature will only be assigned to the integrated buildings. Each building icon will act as an active link to transfer the user to the buildings home screen.
- 3.2.4 At the bottom of the screen will be displayed current outdoor air conditions this information is acquired from a designated campus weather station or sensors located within the building. The cells will not act as links.
- 3.2.5 The bottom of the screen will also contain current time and date information.
- 3.2.6 Top left corner of the screen will have a link to the previous screen.
- 3.2.7 Home Screen: The building home screen will provide the user with an overview of the building energy consumption and building pressurization. A picture of the building will appear in the left hand corner of the screen adding to the esthetic character of the graphic, the picture will not act as an active link.
- 3.2.7.1 Under the building picture will be several links to building systems, floor plans, air systems, water systems, miscellaneous systems and energy reports. When the Air Systems cell is activated, for example, it will expand and show all AHUs, EFs and standalone FCUs which serve the building. Floor plan cell will expand, listing links to all floors. The Water Systems cell will expand to show heating hot water system, chilled water system and/or domestic hot water system. The Energy report link will show current building energy data: Building kW, kWh, tons, kton-hr, Btu/h, Btu w/sqft, sqft/ton, or as installed. Miscellaneous Systems cell will expand to show all remaining systems having graphics which were not covered by previous cells (i.e. compressed air, vacuum, equipment alarms, etc...)

- 3.2.7.2 The alarm bell located further below the building picture will be an indicator and an active link. Bell will have one of two colors – green or red. Green color will inform the user that all building systems are operating normally, while a red color will notify the user that there are systems within the building which are in alarm mode. The alarm bell red color activation will be adjusted per user preference to trigger only if high priority alarms exist in the building. The bell alarm activation will be coordinated to correspond to building color on the site map. It will also allow for a direct link to the alarm management screen.
- 3.2.7.3 Building pressurization indicator will show the building pressure with respect to outdoor. The bar will be divided into green and red area, the green area will represent positive building pressure and the red area will tell the user that the building is negatively pressurized. The numerical indicator cell below the bar will display current building pressure as reported by the building differential pressure sensor. If more than one DP sensor serves the building, the cell will display the worst case building differential pressure.
- 3.2.7.4 Energy demand gauges will display current energy consumption for each measured utility. The gauges scale and resolution will be adjusted to correspond to peak design conditions. The indicator arrows will show the same value as displayed in a cell below the gauge.
- 3.2.7.5 The weather information displayed on the bottom of the screen will feature all outputs from a designated weather station.
- 3.2.7.6 Top left hand corner of the screen will have two links to previous screen and the site map.
- 3.2.8 Large Area Floor Plan Graphic: When a link to a particular floor is selected, the screen will show an overall floor plan view divided into sections. This intermediate screen is necessary in large buildings where detailed floor plan view with room numbers and sensors displaying room air conditions are not possible. In the case of a building with floor plans containing few rooms per floor, this screen can be omitted. The floor plan will accurately represent the as-built layout of rooms in the building.
- 3.2.8.1 The divisions of the partial floor plan sections should be based on the zones served by different air handling equipment. If that strategy does not produce the desired effects, the second best option is to divide the floor plan in equal parts.
- 3.2.8.2 Each section will actively inform user of any alarm conditions within the section by changing from a green to red background color.
- 3.2.8.3 Each section will have a link to take the user to a more detailed floor plan screen. In the bottom left hand corner of the screen are links to other floors arranged in a tree, the three shall also indicate alarm conditions present on each floor.
- 3.2.8.4 Floor Plan Section: The floor plan section screen shows the floor plan layout in more detail with room numbers and sensors displaying room environmental conditions. Each sensor and room number act as a link to the corresponding room system graphic, room background color is green under normal operation and red when any of the analog or binary inputs are outside their alarm limits.

- 3.2.8.5 The bottom left hand corner of the screen features links to different floors described previously, as well as a key plan of the sectioned view of the overall floor plan. Each section acts as an indicator and a link, when any room is in alarm mode in a particular section, that section turns red, otherwise it remains green. The user can move between section screens by selecting the appropriate link. Bottom of the page will have links to associated as-built HVAC, electrical, and piping plans.
- 3.2.8.6 Locations of panel mounted static pressure sensors and building pressure sensors reference points will be indicated on the floor plan graphic.
- 3.2.9 Office: When user selects a link to an office space (by clicking on a room sensor) the graphics screen will bring up a detailed view of the room air terminal and associated sensors. The Screen title block will list the room number which is currently displayed with air terminal name in parentheses. Supply airflow sensor will have the airflow, airflow set-point and velocity pressure listed. Zone temperature will be listed with effective/actual (after local adjustments) heating and cooling set-points, if the temperature deviates outside those set-points the point will go into alarm mode. A parameter list block will act as a link to all points not displayed on the screen. The user will have the ability to change all set-points and settings. All analog inputs will be read only type points with the user having the option of taking the readings out of service. Bottom of the page will have links to associated as-built reference material.
- 3.2.10 General Lab: When user selects a link to general lab space the graphics link will bring up a room with relevant air valves and their associated control points. Air valves will have their respective tags displayed on their icons, (per as-built drawings). The air valve command position and air valve feedback will be listed next to each air valve.
- 3.2.10.1 The screen title block will list the room number with the air valves listed in the parentheses.
- 3.2.10.2 The air change rate information shall be calculated and based on the room volume and the air flowing out of the room. Positive rooms shall use the total supply and negative rooms shall use the total exhaust.
- 3.2.10.3 Zone temperature will have its effective/actual (after local adjustment) heating and cooling set-points listed, if temperature deviates outside those values the point will go into alarm mode.
- 3.2.10.4 All analog will have their corresponding set-points displayed, the parameter list button will be a link to all settings not shown on the room screen. The user will be able to change all settings, all analog and binary inputs will be read only points with the user having the ability to take them out of service.
- 3.2.11 Air Handling Unit – Supply: AHU screen title will show the equipment name.
- 3.2.11.1 All analog points will have their corresponding set-points displayed on the equipment graphic. When the input values are outside their respective set-points, their cells will turn red to show the user that the reading is in an alarm state.
- 3.2.11.2 The user will be allowed to override all output points (AO and DO) settings, all input (AI and DI) settings will be read only with an option of taking their value out of service.

- 3.2.11.3 The outside air damper and return air dampers will have their % open value command and feedback displayed in their indicator cells. The supply air damper status will be indicated by indicator cell and dynamically by making the damper blades move with respect to feedback information.
- 3.2.11.4 Fan status will be shown by color coding the fan wheel green and dynamically spinning the fan wheel when the fan is ON, when fan is OFF the fan wheel will not spin and the fan wheel color will be white. When fan is in alarm mode the fan wheel color will be red. When AHU is equipped with fan array all fans will be shown. VFD box above the fan will provide the user with active links to variable frequency drive integrated information. Supply fan VFD command cell will display the speed of the drive in 0-100%, if the VFD is allowed to exceed 60Hz during normal operation, 100% will correspond to the maximum speed the VFD is allowed to go to. Actual fan hz will be displayed.
- 3.2.11.5 Cooling coil valve command indicator cells will display the % open amount of valve full span and feedback. Chilled water returning from the cooling coil will have its temperature displayed in the indicator cell.
- 3.2.11.6 Filter status will be indicated in the cell and shall flash red when in an alarm state. Filter DP device settings shall be included in graphic when pressure settings are set locally.
- 3.2.11.7 Low temperature alarm, high static alarm and smoke alarm indicator cells will have a green background and display “Normal” when in normal mode, during alarm mode the cell background color will change to red and display will read “Alarm”.
- 3.2.11.8 Information used in discharge temperature reset control loop such as maximum zone temperature and humidity will be displayed in the corner of the screen.
- 3.2.12 Exhaust System with Bypass Damper: Exhaust fan screen title will show the equipment name.
- 3.2.12.1 All analog inputs will have their corresponding set-points listed either on the equipment graphic or in the system parameter box. When the input values are outside their respective set-points, their indicator cells will turn red to show the user that the reading is in alarm mode.
- 3.2.12.2 The user will be allowed to override all output points (AO and DO) settings, all input (AI and DI) settings will be read only with an option of taking their value out of service.
- 3.2.12.3 The bypass dampers will have their % open value and feedback displayed in their indicator cells. The damper status will be indicated by indicator cell and dynamically by making the damper blades move close when damper is closed and open when damper is open.
- 3.2.12.4 Fan status will be shown by color coding the fan wheel green and dynamically spinning the fan wheel when the fan is ON, when fan is OFF the fan wheel will not spin and the fan wheel color will be white. When fan is in alarm mode the fan wheel color will be red. Indicator cell displaying fans lead-lag listing will be shown below each fan, as the fan rotation occurs, the indicator cells will display updated lead lag status in each cell.

- 3.2.12.5 Low static alarm indicator cells will have a green background and display “Normal” when in normal mode, during alarm mode the cell background color will change to red and display will read “Alarm”.
- 3.2.13 Variable Fan Speed Exhaust System with Bypass Damper: Exhaust fan screen title will show the equipment name.
- 3.2.13.1 All analog inputs will have their corresponding set-points listed either on the equipment graphic or in the system parameter box. When the input values are outside their respective set-points, their indicator cells will turn red to show the user that the reading is in alarm mode.
- 3.2.13.2 The user will be allowed to override all output points (AO and DO) settings, all input (AI and DI) settings will be read only with an option of taking their value out of service.
- 3.2.13.3 The bypass dampers will have their % open value and feedback displayed in their indicator cells. The damper status will be indicated by indicator cell and dynamically by making the damper blades move close when damper is closed and open when damper is open.
- 3.2.13.4 Fan status will be shown by color coding the fan wheel green and dynamically spinning the fan wheel when the fan is ON, when fan is OFF the fan wheel will not spin and the fan wheel color will be white. Fan status will be derived from the output power reading of the VFD. When fan is in alarm mode the fan wheel color will be red. VFD box above the fan will provide the user with active links to variable frequency drive integrated points. VFD command cell will display the speed of the drive in 0-100%, if the VFD is allowed to exceed 60Hz during normal operation, 100% will correspond to the maximum speed the VFD is allowed to go to. Indicator cell displaying fans lead-lag listing will be shown below each fan, as the fan rotation occurs, the indicator cells will display updated lead lag status in each cell.
- 3.2.13.5 Low static alarm indicator cells will have a green background and display “Normal” when in normal mode, during alarm mode the cell background color will change to red and display will read “Alarm”.
- 3.2.14 Chilled Water and Hot Water System: Chilled water system screen title will show the system name.
- 3.2.14.1 All analog inputs will have their corresponding set-points listed either on the equipment graphic or in the system parameter box. When the input values are outside their respective set-points, their indicator cells will turn red to show the user that the reading is in alarm mode.
- 3.2.14.2 The user will be allowed to override all output points (AO and DO) settings, all input (AI and DI) settings will be read only with an option of taking their value out of service.
- 3.2.14.3 Valves will have their % open value and feedback displayed in the indicator cells. The pump isolation valve status will be indicated by indicator cell.
- 3.2.14.4 Status will be shown by color coding the impeller wheel green and dynamically spinning the impeller wheel when the pump is ON, when pump is OFF the impeller wheel will not spin and the wheel color will be white. Pump status will be derived from the output power reading of the VFD. When pump is in alarm mode the impeller wheel color will be red. VFD

box above the pump will provide the user with active links to variable frequency drive integrated points. Pump VFD command cell will display the speed of the drive in 0-100%, if the VFD is allowed to exceed 60Hz during normal operation, 100% will correspond to the maximum speed the VFD is allowed to go to. Indicator cell displaying pumps lead-lag listing will be shown below each pump, as the pump rotation occurs, the indicator cells will display updated lead lag status in each cell.

- 3.2.14.5 Include flows and energy data.
- 3.2.15 Variable Frequency Drive: Upon activation of a VFD link on any of the equipment screens the user will be directed to the VFD display screen. The name of the equipment will be displayed in the title block of the screen.
 - 3.2.15.1 The picture of the VFD will show the actual piece of equipment installed in field. All available analog and binary inputs will be shown with appropriate names and units. When VFD is offline all of the indicator cells will turn black.
- 3.2.16 All system graphics shall include links to as-built control diagrams, sequences and product technical data.
- 3.2.17 System Summary Screens: Summary screens shall be developed for each system as described below. All summaries shall be customized for the specific project and application. All system summary screens shall be linked to the specific system graphic, floor plan and/or home page as applicable.
 - 3.2.17.1 General system summary screens (can be generated within any reporting tool)
 - 3.2.17.2 All points in the building.
 - 3.2.17.3 All points in a user-defined group of points including per system log reports.
 - 3.2.17.4 All points currently in alarm in the building.
 - 3.2.17.5 All schedules.
 - 3.2.17.6 All points in an override condition.
 - 3.2.17.7 System specific summary screens.
 - 3.2.17.8 Include an AHU terminal unit summary screen for each AHU that serves multiple terminal units. The summary screen shall include the following information and shall be continuously updated with real time data.

Air Terminal Summary													
Room #	Device ID	Room Temp	Room Target	SA Temp	CLG VLV Cmd	HTG VLV Cmd	Fan S/S	Fan Status	Heat/ Cool	Dmpr Cmd	Air Flow	AHU #	Design CFM

Note 1: Obtained directly from the associated AHU heating hot water return water temperature sensor LW – Leaving Water

Note 2: Obtained from the main building hot water supply sensor EW – Entering Water

3.2.17.12 Include a heating hot water terminal unit summary screen for each building. The summary screen shall include the following information:

Hot Water Reheat Summary			
Terminal #	Heating Coil Supply temp	Htg Valve Command	Actual Airflow
Total			

3.2.17.13 Include an AHU laboratory summary screen for each AHU that serves multiple laboratories. The summary screen shall include the following information:

Laboratory Air Terminal Summary											
Lab #	Supply CFM ¹ Actual	General CFM ¹ Actual	Fume CFM ¹ Actual	CFM Offset Stpt	CFM Offset Actual	% Error	Reheat Valve Command	Htg Coil Sup Temp	Htg Stpt	Temp Actual	Clg Stpt
Total											

Note 1: Sum all supply air terminal, general exhaust terminals and all fume exhaust terminals as applicable.

General Note: %Error = $\frac{\text{Actual Setpoint}}{\text{Setpoint}} \times 100\%$

3.3 Control Wiring and Pathways:

3.3.1 Provide all electrical wiring required for a complete and functional control system, including power circuit to control panels and field devices in accordance with all applicable local codes and the latest version of National Electric Code and NFPA when applicable.

3.3.2 Sizing of cable, conduit, j-boxes and raceways to accommodate system with 25% spare capacity. Minimum conduit size shall be ¾” at all locations. All wall mount devices shall be in conduit and routed to nearest accessible ceiling location stubouts shall be a minimum of 12” from wall line.

3.3.3 Labeled wiring with unique tag to match I/O device identifier tag (e.g. sensor DA-T wire shall be labeled at panel and device as “DA-T”). Communication cable shall be labeled with Loop/Trunk #, previous and destination device (e.g. L1VAV101/VAV102 would be used to label the loop 1 communication bus between VAV101 and VAV102)

3.3.4 Low voltage wiring concealed above accessible ceilings does not require raceway, however, cables run above accessible ceilings shall be run within a j-hook pathway system spaced no more than 4 ft apart. Cables run in concealed areas or within un-accessible spaces shall be installed in EMT. Run pathways and cables parallel and perpendicular to building structure.

3.3.5 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit shall be UL listed.

3.3.6 Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to converter cables in accordance with drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

3.3.7 BAS Network Communication Cable:

- 3.3.7.1 Run communication or low voltage power cable in separate pathways or in j-hooks with proper clearances.
- 3.3.7.2 Install special cable connectors in accordance with manufacturer's recommendations.
- 3.3.7.3 BAS network communication cable shall not be spliced unless a terminal strip enclosure is used.
- 3.3.7.4 BAS network communication shall be shielded with the shields taped back where applicable.
- 3.3.8 All control wiring located in mechanical or exposed spaces shall be run in EMT.
- 3.3.9 All Input / Output wiring shall be shielded in accordance with equipment requirements.
- 3.3.10 Refer to Division 16 for additional requirements, except as noted.
- 3.3.11 Control panels and operator's terminals serving equipment fed by emergency power shall also be served by emergency power. Locate LOT and its UPS where shown on plans.
- 3.3.12 Power wiring to control compressors and dryers shall be as indicated on electrical power plans. Provide field mounted starters to Electrical Contractor for installation and supervise installation.
- 3.3.13 Raceway Identification. All the covers to junction and pull boxes of the BAS raceway system shall be painted white.
- 3.4 Air Piping:
- 3.4.1 Conceal all piping, except for piping in mechanical rooms and other areas where mechanical system piping is exposed.
- 3.4.2 Install exposed piping and conduit parallel to or at right angles to building structure and support adequately at uniform intervals. Use only tool-made bends.
- 3.4.3 Polyethylene tubing not exceeding 18" may be used for final connection to instrument or actuator except in high temperature locations such as mechanical rooms with steam heat exchangers or areas exposed to outside environment. Use hard copper for these applications.
- 3.4.4 Install polyethylene tubing with no concealed splices and number code all tubing.
- 3.4.5 Make tests on sectional piping during progress of installation to ensure no leakage.
- 3.4.6 Provide cartridge type desiccant dryers for air lines passing through outside air stream or through unheated spaces where space temperatures can be below 30°F.
- 3.4.7 Piping type shall be as follows:
 - 3.4.7.1 Inside Panels:

- 3.4.7.1.1 Use polyethylene tubing.
- 3.4.7.2 Piping Serving Smoke Dampers and Combination Fire-Smoke Dampers:
 - 3.4.7.2.1 Use hard copper for mains and exposed piping and hard or soft copper for branches and concealed piping.
- 3.4.7.3 Exposed Spaces:
 - 3.4.7.3.1 Use hard copper tubing or
 - 3.4.7.3.2 Polyethylene tubing may be used if run in fully enclosed EMT raceway where environment is within temperature limits of polyethylene tubing.
 - 3.4.7.3.3 Use PVC coated copper tubing for wet environments.
- 3.4.7.4 Concealed:
 - 3.4.7.4.1 Use hard copper, soft copper or polyethylene tubing.
- 3.4.8 Concrete Buried:
 - 3.4.8.1 Use hard copper, soft copper or polyethylene tubing in metal or plastic conduit.
- 3.5 Air Supply System:
 - 3.5.1 Provide an appropriate air pressure reducing station connected to the existing piping system and providing a new refrigerated air dryer assembly for the piping extension, all having the required system capacity to serve the devices included in the Vendor / Installer's work.
 - 3.5.2 Install air compressor assembly where indicated on drawings.
 - 3.5.2.1 Pipe tank drain to nearest floor drain.
 - 3.5.2.2 Install vibration isolators as recommended by manufacturer.
 - 3.5.3 Install air dryer assembly where indicated on drawings or suitable location adjacent to air compressor assembly.
 - 3.5.3.1 Mount air dryer on wall with suitable supports.
 - 3.5.3.2 Pipe unit drain to nearest floor drain.
- 3.6 Local Control Panels:
 - 3.6.1 Provide local control panel for each system where more than one control device requires field mounting (air handling units, miscellaneous control system including pump controls, etc.). Single devices may be mounted exposed on piping or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served. Do not mount panels on equipment.

- 3.6.2 Mount panel on wall with suitable brackets or on floor with self-supporting stand.
 - 3.6.2.1 Mount top of panel no higher than 6 feet above floor.
 - 3.6.2.2 Install panels so front cover door can swing full open without interference and maintain a minimum of 36" clearance.
- 3.6.3 Unless otherwise indicated, mount controllers, adjusting switches, pressure gages, temperature indicators and other indicating or manually operated devices inside panel with permanent labels identifying device and controlled device or function.
- 3.6.4 In-line pneumatic gages shall be hard mounted to back panel and shall include permanent labels identifying end device. Other factory standard labeling methods are acceptable as long as the device name and function is clearly identified and is permanent. Labels shall correspond to control drawing tags and identifiers.
- 3.6.5 Labels shall correspond to control drawing tags and identifiers.
- 3.6.6 Panel will be labeled with location and breaker number of power feed.
- 3.7 Network Routers & Bridges:
 - 3.7.1 Coordinate final location with Owner and other trades.
- 3.8 Building Level Controller:
 - 3.8.1 Provide controllers as required.
 - 3.8.2 Coordinate final location with Owner other trades.
- 3.9 Advanced Application Controllers – Hardware (AAC):
 - 3.9.1 Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
 - 3.9.2 Size controller to meet the requirements of this specification and the project point I/O schedule +15% additional capacity of each point type.
- 3.10 Application Specific Controllers (ASC's):
 - 3.10.1 Provide the following types of application specific controllers (embedded or as a predefined software application) as a minimum:
 - 3.10.1.1 Variable Air Volume (VAV) boxes
 - 3.10.1.2 Constant Air Volume (CAV) boxes
 - 3.10.1.3 Fan Coil Units
 - 3.10.1.4 Unit Conditioners
 - 3.10.1.5 Heat Pumps

- 3.10.1.6 Unit Ventilators
- 3.10.1.7 Small AHU'S
- 3.10.1.8 Room Pressurization

- 3.11 Electrical Power Meter:
 - 3.11.1 Furnish power meter as shown on drawings and/or as required to perform control sequence specified.
 - 3.11.2 Provide communication to the BAS.
 - 3.11.3 Coordinate location and power requirements with other trades.

- 3.12 Servers:
 - 3.12.1 Archive all historical data such as trends, alarm and event histories, and transaction logs on existing server.

- 3.13 Control Valves:
 - 3.13.1 Furnish control valves as shown on drawings and/or as required to perform control sequence specified.
 - 3.13.2 Coordinate the installation of control valves.
 - 3.13.3 Control valves furnished by this contractor shall be installed by **[Division 15XXX Contractor]** under coordinating control and supervision of this Contractor.
 - 3.13.4 Sizing:
 - 3.13.4.1 Select control valves to meet their intended service without cavitations. Provide cavitation calculations for modulating globe control valves over 250°F and all modulating butterfly valves over 60°F.
 - 3.13.4.2 Valve body ratings indicated in Part 2 are minimum required. Valve body, trim and packing selected shall be designed to withstand maximum pressure and temperature encountered in the systems.
 - 3.13.4.3 Submit engineering calculations used for sizing modulating control valves. Control valves serving terminal devices may be sized based on flow ranges for each pump system.
 - 3.13.4.4 Calculations for sizing modulating valves shall be based on actual characteristics of equipment and system being installed.
 - 3.13.4.4.1 Valve calculations shall include information such as pump head or available pressure; branch piping circuit losses including all pipe, fittings, valves, and coils; flow rates; and pressure losses of other in-line devices.
 - 3.13.4.4.2 Obtaining adequate system information necessary for sizing valves.

- 3.13.4.5 Design criteria for sizing modulating valves shall be based on two port, or 3 port, fail open or fail closed, as shown on plans, equal percentage valves unless otherwise specified.
- 3.13.4.6 Heating control valves shall be full port ball valve and shall be selected for a minimum of 25% of equipment subcircuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balance valve.
- 3.13.4.7 Size three-way mixing or diverting valves not directly associated with pump sub-circuit, for [3-5] psi pressure drop.
- 3.13.4.8 Terminal reheat control valves shall be ball type and shall be selected for a minimum of 25% of equipment subcircuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balance valve.
- 3.13.4.9 Cooling control valves may be full port ball, or butterfly type and shall be selected for minimum of 10% of equipment subcircuit pressure drop, but not more than maximum available pump head allowing minimum 2 psi drop for balance valve.
- 3.13.4.10 Select control valves based on pressure drop calculations using Cv values at 100% stroke.
- 3.13.4.11 Subcircuit is defined as all branch supply and return piping to terminal device, including all valve, coil, control valves, and balance valve.
- 3.13.5 **Steam Valves:**
- 3.13.5.1 Modulating steam control valves shall be straight-through globe type with linear characteristics for 90% of closing stroke and equal-percentage for final 10%.
- 3.13.5.2 For steam inlet pressure less than 15 psig, size valves for pressure drop equal to 75 to 80% of gauge inlet steam pressure.
- 3.13.5.3 For steam inlet pressure of 15 psig or greater, size valves for pressure drop equal to 50% of absolute inlet pressure.
- 3.14 **Control Dampers:**
- 3.14.1 Furnish control dampers as shown on drawings and/or as required to perform control sequence specified except those furnished with other equipment.
- 3.14.2 Coordinate the installation of control dampers.
- 3.14.3 Control dampers furnished by this Contractor will be installed by [Division 15XXX Contractor] under coordinating control and supervision of this Contractor.
- 3.14.4 Blank-off plates or transitions required to facilitate dampers will be provided by the [Division 15XXX Contractor].
- 3.15 **Actuators and Pilot Positioners:**

- 3.15.1 Provide actuator for each automatic damper or valve with sufficient capacity to operate damper or valve under all conditions. Select actuators to provide tight shut off against maximum system temperatures and pressure encountered.
- 3.15.2 [Provide pilot positioners for pneumatic modulating valves and dampers for major equipment such as air handling unit coils, humidifiers, heat exchangers, converters, major water system temperature controls, etc.]**
- 3.15.3 Valve and damper operating speeds shall be selected or adjusted so operators will remain in step with controller without hunting regardless of load variations.
- 3.15.4 Provide proper linkage and brackets for mounting and attaching actuators to devices. Design mounting and/or support to provide no more than 5% hysteresis in either direction (actual movement of valve stem/damper shaft/ideal movement) due to deflection of actuator mounting.
- 3.15.5 Sizing
- 3.15.5.1 Calculations for sizing dampers shall be based on actual characteristics of ductwork system being installed.
- 3.15.5.2 Opposed blade dampers shall be sized for minimum of 10% of duct section pressure drop. Parallel blade dampers shall be sized for minimum of 30% of duct section pressure drop. Duct section is defined as ductwork containing flow control damper starting with inlet or branch tee and ending with outlet or branch tee.
- 3.15.5.3 Calculate actual duct pressure drops for each duct section containing modulating damper using latest version of ASHRAE Handbook of Fundamentals.
- 3.15.5.4 If control system fixes pressure drop, use those pressure setpoints. Use duct blank-offs to provide additional pressure drop as required to obtain linear damper response.
- 3.15.5.5 Contractor is responsible for obtaining adequate system information necessary for sizing.
- 3.15.5.6 Contractor to provide dampers as shown on drawings or as scheduled.
- 3.15.5.7 Two position dampers shall be sized as close as possible to duct size, but in no case is damper size to be less than duct area.
- 3.16 General Instrumentation:
- 3.16.1 Pressure Gauges (Pressure Indicators):
- 3.16.1.1 Install pressure gauges for indication of supply and control pressure in pneumatic systems at output of I/P transducers, electric air solenoid valves and pressure switches, actuators and other points where visible indication of air pressure is required for operating and maintenance purposes (include a pressure gage with 12 inches of controlled device).
- 3.16.1.2 Furnish pressure gauges with tappings for piping.
- 3.16.1.3 Provide pressure gages in control panel and at end device (pneumatic actuators). End device pressure gage shall be mounted so that gage can be easily seen from eye level.

3.16.2 Water Differential Pressure Sensors

- 3.16.2.1 Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device. Transmitter range shall be selected for mid-range values while operating under normal operating range.
- 3.16.2.2 Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines. Test ports shall be included for 3rd party verification.
- 3.16.2.3 Differential pressure transmitter shall include a separate pressure gage scaled to indicate normal operating range of device. This pressure gage shall be installed in parallel with sensing lines.
- 3.16.2.4 The transmitters shall be installed in an accessible location whenever possible.

3.17 Discrete Electric Instrumentation:

3.17.1 General:

- 3.17.1.1 Terminate at terminal blocks inside enclosures unless otherwise specified.
- 3.17.1.2 Include auxiliary contact for remote status indication of safety devices.

3.17.2 Temperature Switches (Electric Thermostats):

- 3.17.2.1 Provide temperature switches as shown or as required for sequence of operation.

3.17.3 Low Limit Temperature Switches (Freeze Stats):

- 3.17.3.1 Install low limit controls where indicated on drawings or as specified. Unless otherwise indicated, install sensing element at downstream side of heating coils.
- 3.17.3.2 Distribute sensing element across entire area of medium being sensed. Install controls at accessible location with suitable mounting brackets and element duct collars where required.
- 3.17.3.3 Serpentine sensing element, starting at the lowest point (6" above coil bottom) of the coil being protected. Operation of low limit trip shall provide protection to associated coils.
- 3.17.3.4 Low limit trip activation shall cause all water coils to be overridden to full flow.

3.17.4 Relays:

- 3.17.4.1 Provide control relays where indicated on drawings or as required to accomplish sequences.
- 3.17.4.2 Provide DIN mounted relays in control panels.
- 3.17.4.3 Provide RIB type relays for field control devices mounted on exterior of starter or VFD.
- 3.17.4.4 Mount relay for easy accessibility.

- 3.17.4.5 Mount relay for easy visual accessibility.
- 3.17.5 Pressure Switches:
 - 3.17.5.1 Provide pressure switches where indicated on drawings or as required to accomplish sequences.
 - 3.17.5.2 Coordinate installation of flow switches for proper location and installation.
- 3.17.6 Pressure Switches (Air Side):
 - 3.17.6.1 Pressure Switches: Provide pressure switches where indicated on drawings or as required to accomplish sequences.
 - 3.17.6.2 Coordinate installation of flow switches for proper location and installation.
 - 3.17.6.3 Alarm setpoint value to be indicated on field installed device.
- 3.17.7 Target Type (Paddle) Flow Switches:
 - 3.17.7.1 Furnish paddle switches as required.
 - 3.17.7.2 Coordinate installation of flow switches for proper location and installation.
- 3.17.8 Flow Switches:
 - 3.17.8.1 Furnish flow switches as required.
 - 3.17.8.2 Coordinate installation of flow switches for proper location and installation.
- 3.17.9 E-P Switches (Solenoid Valves):
 - 3.17.9.1 Provide E-P switches where indicated on drawings or as required to accomplish sequences.
- 3.17.10 Position Switches (End Switch):
 - 3.17.10.1 Provide position switches where indicated on drawings or as required to accomplish sequences.
- 3.17.11 Current Switches:
 - 3.17.11.1 Provide current switches where indicated on drawings or as required to accomplish sequences.
 - 3.17.11.2 Locate in starter or VFD or in an appropriate adjacent enclosure.
- 3.17.12 Transmitters and Indicators:

- 3.17.12.1 Locate transmitters at sensing device or within 100 ft for remote mounted transmitters. For hot systems (150°F and higher) mount electronics on side of pipe or remotely mount. For indicating type instruments, locate indicating element within 6 ft of floor with readout easily visible from floor level. Provide remote readouts if necessary.
- 3.18 Analog Electronic Instrumentation:
 - 3.18.1 Metering and Totalization:
 - 3.18.1.1 Coordinate the delivery and installation of meter.
 - 3.18.1.2 Installation where indicated on drawings.
 - 3.18.1.3 Mount remote display unit at eye level in accessible location.
 - 3.18.2 Differential Pressure Transmitter:
 - 3.18.2.1 Provide differential pressure transmitter for building [**chilled water/hot water**] differential pressure.
 - 3.18.2.2 Coordinate the location with other trades.
 - 3.18.3 Wall Mounted Space Sensors:
 - 3.18.3.1 Install space thermostats/sensors where indicated, as required to perform specified controls, or directed to meet job site conditions.
 - 3.18.3.2 Mount space sensors 4 ft above floor unless otherwise indicated.
 - 3.18.3.3 Any room sensor mounted on exterior walls shall be mounted on thermally insulated sub-base.
 - 3.18.3.4 Relocate room sensors if required due to draft, interferences with cabinets, writing board, etc., or improper sensing.
 - 3.18.3.5 Room sensors in gymnasium, locker rooms and [XXX] shall be protected by heavy-duty cast and die formed guard.
 - 3.18.3.6 Provide a conduit from sensor box to above the ceiling where it shall stub out into an accessible area parallel with the ceiling.
 - 3.18.4 Room Thermostats
 - 3.18.4.1 Install space thermostats where indicated, as required to perform specified controls, or directed to meet job site conditions.
 - 3.18.4.2 Mount thermostats at 4 ft above floor unless otherwise indicated.
 - 3.18.4.3 Any room thermostat mounted on exterior walls shall be mounted on thermally insulated sub-base.

- 3.18.4.4 Relocate room thermostats if required due to draft, interferences with cabinets, writing board, etc., or improper sensing.
- 3.18.4.5 Provide thermostats in gymnasium, locker rooms and [XXX] heavy-duty cast and die formed guard.
- 3.18.4.6 Provide a conduit from thermostat box to above the ceiling where it shall stub out into an accessible area parallel with the ceiling.
- 3.18.5 Duct Mounted probe Sensors:
 - 3.18.5.1 Provide sensors where shown on drawings or to accomplish sequences.
 - 3.18.5.2 Install outside air sensors in weatherproof, non-corrosive solar shield.
- 3.18.6 Insertion Temperature Sensors
 - 3.18.6.1 Provide sensors where shown on drawings or to accomplish sequences.
 - 3.18.6.2 Install wet sensors in stainless steel or brass wells with thermal grease.
- 3.18.7 Duct Mounted Averaging Temperature Sensors:
 - 3.18.7.1 Use where temperatures are prone to stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required. All sensors located within the AHU compartment shall be averaging.
 - 3.18.7.2 Serpentine sensor in duct to maximize coverage of measured area.
 - 3.18.7.3 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - 3.18.7.4 Mounted to suitable supports using factory approved non-metal element holders.
- 3.18.8 Dew Point or Wet Bulb Temperature Transmitter:
 - 3.18.8.1 Provide dew point transmitters where indicated or to accomplish sequences.
- 3.18.9 Space Humidity Sensors/Transmitters:
 - 3.18.9.1 Install space humidity sensor where indicated, as required to perform specified controls, or directed to meet job site conditions.
 - 3.18.9.2 Mount sensors at same height as temperature sensors.
 - 3.18.9.3 Any sensor mounted on exterior walls shall be mounted on thermally insulated sub-base.
 - 3.18.9.4 Relocate room thermostats if required due to draft, interferences with cabinets, chalkboards, etc., or improper sensing.

- 3.18.9.5 Provide sensors in gymnasium, locker rooms and [XXX] heavy-duty cast and die formed guard.
- 3.18.9.6 Provide a conduit from sensor box to above the ceiling where it shall stub out into an accessible area parallel with the ceiling.
- 3.18.10 Duct Mounted Humidity Sensors/Transmitters:
 - 3.18.10.1 Provide duct humidity sensor where indicated, as required to perform specified controls, or directed to meet job site conditions.
- 3.18.11 Thermal Dispersion or Vortex Shedding Air Flow Sensors/Transmitters:
 - 3.18.11.1 Provide air flow sensor where indicated, as required to perform specified controls, or directed to meet job site conditions.
- 3.18.12 P-E Transducers (Pressure Transmitters):
 - 3.18.12.1 Provide transducers as required to perform specified controls, or directed to meet job site conditions.
 - 3.18.12.2 Mount transducers in control panels.
 - 3.18.12.3 Provide gauge for all transducers.
- 3.18.13 Ducted Air System Static Pressure and Differential Pressure (Velocity) Transmitters:
 - 3.18.13.1 Provide transducers/transmitters to convert velocity pressure differential or static duct pressure relative to sensor location into electronic signal.
 - 3.18.13.2 Mount transducers in control panels.
 - 3.18.13.3 Terminate transducers directly to the controller that is implementing control loop.
- 3.18.14 Building and Space Pressure Differential Transmitter:
 - 3.18.14.1 Provide directional mass flow transmitter installed in 2" thin-wall rigid conduit (EMT) or PVC between spaces to measure relative velocity created by the pressure difference.
 - 3.18.14.2 Extend 2" EMT or PVC pipe between spaces for room pressure control, or between space and outside for building static pressure control.
 - 3.18.14.3 Provide algorithm in software to convert air velocity to pressure differential ($DP = C (V/4005)^2$). Field determine coefficient C by calibrated measurement.
 - 3.18.14.4 Construct shroud of aluminum, painted to match building exterior.
- 3.18.15 Electric to Pressure Transducers:

- 3.18.15.1 Provide pressure transducers integral to DDC panels or separate components to convert digital analog signal to variable pneumatic air pressure signal.
- 3.18.15.2 Provide output gauge for all transducers.
- 3.18.15.3 Mount in control panel.
- 3.18.16 Carbon Dioxide Sensor:
 - 3.18.16.1 Provide carbon dioxide sensor where indicated, as required to perform specified controls, or directed to meet job site conditions.
- 3.18.17 Terminal Unit Location Identification:
 - 3.18.17.1 Provide a label directly below terminal unit devices mounted above ceiling. Label the approximate location on ceiling grid. Where associated devices such as reheat valves are not mounted with the terminal unit provide additional labels to indicate all device locations.
- 3.19 Spare Parts:
 - 3.19.1 Contractor shall provide to the Owner the following spare parts:
 - 3.19.1.1 Three (3) APPLICATION SPECIFIC CONTROLLERS (ASC) as used on the project.
 - 3.19.1.2 Three (3) each of each analog temperature and pressure sensors used on the project.
 - 3.19.1.3 Three (3) each of each digital input devices (current sensors, pressure switches, etc.) used on the project.

END OF SECTION