SECTION 230593 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

A. TAB contractor shall assist the ATC controls contractor to ensure all airflow, waterflow, static pressure setpoints, etc.. are transferred from the existing BAS system to the new BAS system. Where the information cannot directly be extracted from the existing BAS, the TAB contractor shall take manual readings.

B. TAB contractor shall provide calibration of all sensors and devices as required for proper operation in the new BAS. Determine calibration factors.

C. Pre-Demo Measurement, Testing and Report:

1. Provide pre-demolition testing of all air-side equipment (AHU's to Air Terminals). Document airflow (max, min, and heating) and all other values required to accomplish the sequence of operations.

a. Air Terminals can be documented thru extraction information from the existing BAS. Direct measurement only required if information is unavailable.

b. Provide direct readings of all Air Handling Units, Heating and Ventilation Units, and Make-Up Air Units in addition to documenting the information in the existing BAS.

2. Provide report for owner and engineer review and approval.

D. Post-Installation Measurement, Testing and Report:

1. Provide testing, adjusting and balancing of all air-side equipment (AHU's to Air Terminals).

2. Provide testing, adjusting and balancing of all water-side equipment (pumps, coils, etc.).

3. The Owner shall provide a recent Retro Commissioning report for rebalancing of the systems. Where information is not available on this report, values shall be balanced back to the pre-demolition values.

4. TAB contractor shall work with the ATC Contractor to facilitate entering the flow values into the unit controllers and calibration of the correction coefficients. For example, the TAB contractor will need to calibrate the correction coefficients (k factor) on the air terminal units since the controllers are being changed.

E. Extent of testing, adjusting, and balancing (TAB) work required by this section is indicated on drawings and schedules, and by requirements of this section, and is defined to include, but is not necessarily limited to, air distribution systems, hydronic distribution systems, and associated equipment and apparatus of mechanical work. The work consists of setting speed and volume (flow), adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports to achieve the capacities or setpoints indicated on the contract documents, and recommending modifications to work as required to achieve the capacities or setpoints indicated on the contract documents.

F. Component types of testing, adjusting, and balancing specified in this section shall include, but not be limited to, the following as applied to mechanical equipment:

1. Building automated system

2. Fans (Smoke Exhaust, General Exhaust, Toilet Exhaust Supply, Return, Relief, etc…)

3. Air handling Units, Heating and Ventilation Units, Makeup Air Units, etc.

4. Fan Coil Units, Split-System AC Units, and Heat Pumps

5. Balancing Valves and hydronic coils (Chilled Water, Heating Water, and Domestic Heating Water Systems)

6. Air Terminal Units (CAV, VAV, single-duct and fan-powered units)

7. Air devices - EXCLUDED

8. Air flow Measuring Stations

1.2 QUALITY ASSURANCE

A. Tester's Qualifications: A firm certified by Associated Air Balance Council (AABC) who is not Installer of system to be tested.

1. AABC Compliance: Comply with the current AABC's Manual "AABC National Standards", as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.

2. Industry Standards: Comply with AABC recommendations pertaining to measurements, instruments, and testing, adjusting, and balancing, except as otherwise indicated.

3. ASHRAE Standard 111: Comply with current edition of ASHRAE 111, “Measurement, Testing, Adjusting and Balancing of HVAC Systems”.

4. Independence: TAB contractor shall be independently owned and operated with no affiliation with the general contractor, mechanical contractor, sheet metal contractor, design engineer, etc.

5. Experience: Each technician shall demonstrate a minimum of three years of actual test and balance field experience.

B. Pipe Testing Procedures: Contractor shall pressure test all piping systems in accordance with the following:

1. ASME Code for Pressure Piping B31, most current edition.

2. National Fire Protection Association (NFPA), all applicable sections, most current edition.

1.3 SUBMITTALS

A. Qualification: TAB contractor qualifications shall be provided as a formal submittal for review to demonstrate conformance with all qualifications indicated throughout the contract documents.

B. Submit certified test reports, signed by the AABC Test and Balance technician who performed the TAB work. In addition, the report shall be certified by an AABC certified Test and Balance Engineer (T.B.E.) who is familiar with the project.

1. Include identification and types of instruments used, and their most recent calibration date with submission of final test report.

2. Provide Pre-Demolition Test Report

3. Provide Post-Installation Test Report

C. The Contractor shall maintain a copy of AABC standards on the site during all TAB work. Said document(s) shall be made available to Owner representatives for reference as to minimum requirements.

D. Maintenance Data: Include in maintenance manuals, copies of certified test reports, identification of instruments.

1.4 JOB CONDITIONS

A. Do not proceed with testing, adjusting, and balancing work until work has been completed, tested, operable, and all balancing devices indicated on the contract documents have been installed. Ensure that there is no residual work still to be completed on the equipment to be tested.

B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt and discarded building materials.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.

1. Factory fabricated plastic plugs shall be used to patch drilled holes in ductwork and housings.

2.2 TEST INSTRUMENTS

A. Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in the following TAB standards:

1. AABC's Manual "AABC National Standards".

2. Wherever permanently installed measuring equipment is provided, such as air volume monitors, flow meters, temperature and pressure gages, etc., these shall be used in addition to TAB instrumentation. Any discrepancies in accuracy shall be brought to the attention of the Owner. Where permanently installed instrumentation meets accuracy requirements for TAB work, they may be used provided TAB Contractor can verify calibration of installed instruments.

B. The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser air flow measurements.

PART 3 - EXECUTION

3.1 FIELD WORK

A. Prior to the mechanical installation, the mechanical and TAB contractors shall review the design documents for “balanceability” to confirm that all devices required to properly balance each system are to be provided under this contract. Recommended modifications and/or additions shall be made directly to the engineer and a minimum of 30 days prior to the installation of mechanical equipment.

B. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned, operable and accessible. Do not proceed with TAB work until unsatisfactory conditions have been corrected.

C. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable AABC standards. All systems and components shall be balanced within ±5% of design air and water flows.

D. Test, adjust and balance system during summer season for cooling and during winter season for heating systems, including operation at outside conditions within 3°F (2°C) wet bulb temperature of maximum summer design condition, and within 10°F (6°C) dry bulb temperature of minimum winter design condition. When seasonal operation does not permit measuring final temperatures, then take final temperature readings when seasonal operation does permit.

E. Patch holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer.

3.2 REPORTS

A. Prepare report of test results, including instrumentation calibration reports, in format recommended by AABC standards. Provide a System Summary page(s) at the front of the report.

B. An interim/preliminary handwritten report shall be submitted to the Engineer for review prior to the formal submission of the report.

C. Test reports shall include, but not be limited to, the following information:

1. Air Handling Equipment Test:

a. Air handling equipment shall include, but not be limited to, all fans (supply, exhaust, return, relief, make-up, ventilation, etc.), air handling units, fan coil units, etc.).

b. Design Conditions: CFM, static pressure, motor h.p., outside air CFM (where applicable), fan and motor RPM and fan motor h.p. for each fan.

c. Installed Equipment: Manufacturer, size, arrangement, class, motor h.p., volts, phase, cycles, and full load amps.

d. Field Test Results: Fan CFM, fan RPM, fan motor voltage, fan motor operating amps, fan motor operating b.h.p., total static pressure for each fan. In addition, where applicable provide external static pressure, air pressure drop across each coil, filter bank, attenuator, etc. (i.e.. provide total static pressure profile of each system), as well as leaving air temperature, outside air conditions (dry bulb/wet bulb) at time of test, coil flow data (GPM), coil entering and leaving air temperatures, coil entering and leaving water temperatures, coil water pressure drop, VFD settings at final test conditions, and duct static pressure setpoint. Air temperature difference measurements will not be acceptable.

2. Air Distribution Test: Main and major branch ducts and individual supply, return and exhaust terminals (VAV terminals, terminal reheat units,):

a. Design Conditions: Ductwork: CFM, duct size. Air terminals, diffusers, registers, grilles: CFM, module size and inlet size.

b. Field Test Results: Ductwork: CFM, duct size, number of velocity readings, average velocity reading. Air terminals, diffusers, registers, grilles: CFM, module size and inlet size.

3. Pump Test:

a. Design Conditions: GPM, Head, RPM, motor h.p.

b. Installed Equipment: Manufacturer, size, type drive, motor h.p., volts, phase and cycles, full load amps.

c. Field Test Results: Shut-off head, discharge pressure, suction pressure, GPM, operating head, pump motor operating amps, pump motor operating b.h.p., VFD settings at final test conditions and differential pressure setpoint.

4. Heat Exchanger Test:

a. Design Conditions: GPM, water pressure drop, entering and leaving fluid temperatures. For chillers provide flow, pressure drop and temperature differential for chilled and condenser water, as well as compressor power input readings.

b. Field Test Results: GPM, water pressure drop, entering and leaving fluid temperatures and outside air conditions (dry bulb/wet bulb) at time of test. For chillers provide flow, pressure drop and temperature differential for chilled and condenser water, as well as compressor power input readings.

5. Miscellaneous Test Results:

a. All Coils: Air pressure drop, water pressure drop, water flow (GPM), air flow (CFM), entering water temperature, leaving water temperature, entering air temperature, leaving air temperature and outside air temperature at time of test (where applicable) and BTU calculations. Air temperature difference methods will not be acceptable.

b. Air Flow Monitors (AFM): Provide verification of AFM accuracy including set-up and adjustment required to verify proper operation and accuracy of each AFM system.

D. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced; including, where necessary, modifications which exceed requirements of contract documents for mechanical work.

E. Record outdoor air temperature (dry bulb and wet bulb) at the time of testing air handling units and any other equipment where performance is affected by outdoor air conditions.

3.3 TESTS - EQUIPMENT

A. The contractor shall verify calibration of all indicating, recording, controlling and controlled devices throughout the mechanical system. Verify the proper function of all installed equipment and devices and the interlocking of all new systems as required by the contract documents.

B. A report including successful calibration and function performance verification of all items indicated above shall be included in the Operations and Maintenance Manual.

3.4 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.

B. Comply with all applicable specification sections including, but not be limited to, “Basic HVAC Requirements”, “Testing, Adjusting and Balancing”, “Automatic Temperature Controls” and “Commissioning”, where applicable.

C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A verification calibration report shall be provided with the final test report.

D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.

E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.

F. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.

G. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.5 FINAL TESTS, INSPECTION AND ACCEPTANCE

A. At time of final inspection, Contractor shall recheck, in presence of Owner's Representative, random selections of data (water and air quantities, air motion, and sound levels) recorded in Certified Report. In addition, courtrooms, auditoriums, and conference rooms shall be rechecked. [Laboratories shall be rechecked for satisfactory air flow and motion in vicinity of and through hoods.]

1. Points and areas for recheck shall be selected by Owner's Representative.

2. Measurement and test procedures shall be same as approved for work forming basis of Certified Report.

3. Selection for recheck (specific plus random), in general, will not exceed 25 percent of total number tabulated in report, except that special air systems may require a complete recheck for safety reasons.

B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from, or a sound level of 2 db or more, greater than that recorded in Certified Report listings, at 10 percent or more of the rechecked selections, report shall automatically be rejected. In the event the report is rejected, systems shall be readjusted and tested, new data recorded, new Certified Reports submitted, and new inspection tests made, at no additional cost to the Owner.

C. Marking of Settings: Settings of valves, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time.

END OF SECTION 230593

SECTION 230900 - AUTOMATIC CONTROL SYSTEMS (ELECTRIC-ELECTRONIC)

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: The extent of automatic controls work is indicated on the drawings and schedules and by the requirements of this Section, and all other Division-23 sections. The work includes, but is not limited to the following:

1. M&T Bank Stadium shall be provided with a new fully digital building automation system (bas). This system will replace the existing Johnson DDC control system & Andover Continuum control system in their entirety, unless otherwise noted.

   All identified equipment (see floor plans) is existing to remain and shall be retrofit with new controls (i.e. sensors, dampers, etc…). All equipment shall be connected to the new BAs. Refer to ATC controls drawings for additional information.

   All existing thermostats related to work shown on plans or in sequences shall be removed and replaced.

   All existing valves and dampers are pneumatically actuated. Replace all pneumatic actuators with electronic actuators.

2. The ATC work shall include provisions for a complete and operable control system, including all devices required to achieve the sequences and functions indicated throughout the contract documents. The contractor shall have a dedicated person for BAS systems integration.

3. The contractor shall furnish and install all electrical wiring and conduit from power source, including termination to all required ATC related power connections including, but not limited to, DDC controllers (provide low voltage controller for air terminal units including transformers and disconnect switches as required), sensors, valve and damper actuators (including smoke dampers), air flow monitors, ATC panels, etc. The Contractor shall be wholly responsible for all power requirements necessary for a complete installation from the power source to all ATC related connections.

4. The Contractor shall coordinate and verify that all controllers, devices and accessories are provided as required to accomplish all control functions and sequences indicated in the contract documents. Where control related devices are not provided by an equipment manufacturer, it shall be the responsibility of the Contractor to provide the control devices required to accomplish the functions and sequences indicated.

5. The Contractor shall provide new controllers, devices, points, etc required to accomplish the control sequences and functions indicated on the drawings and in the specifications. Existing controllers and devices shall be demolished and not be re-used for this project. All points shall be tied into the building automation system (BAS). In addition, the Contractor shall provide all controllers, devices, points, etc required to control, operate and monitor all equipment indicated throughout the contract documents.

6. The provision of 120 and 208 volt line voltage and 5 and 24 volt low voltage wiring and conduit types shall be installed in accordance with Division-26 of these specifications.

7. The Contractor shall interface with fire alarm devices as required to accomplish equipment shutdown, alarms, etc. indicated in sequences.

   a. Smoke control components: All control devices and wiring used for the smoke control systems shall meet the UL 864, UUKL listing requirements.

8. All drilling, cutting and patching associated with the installation of control systems.

B. Types: Provide automatic control systems of the following types:

1. Direct Digital Control (DDC) with electric actuation of valve and damper actuators.

2. The automatic temperature control system shall include remote interface and web access capability. All building management system control features including, but not limited to, points, alarms, scheduling, graphics, trending, etc. shall be available for control and monitoring through web access as well as remote interface (coordinate exact location with the using agency, where applicable).

C. Not used..

D. Establish existing conditions for a baseline. All currently monitored and controlled points in the existing BAS shall be verified and the same functionality shall be included in the new BAS.

1. Document all currently monitored and controlled points in the existing BAS. Document all current custom reports and templates.

2. Contractor shall use the available BAS record documents, the current BAS workstation, and Owner's facility personnel to establish the baseline existing system.

E. Related Sections: Possible related sections include, but shall not be limited to, the following:

1. Section 25 00 10 Intelligent Building Management System (iBMS)

1.2 QUALITY ASSURANCE

A. Systems Engineering: The systems engineering phase shall include the selection and integration of components into a complete system which will meet the performance and prescriptive requirements of the Contract, together with drawings, specifications, descriptions of operation, diagrams and other materials listed under "Submittals" paragraph of this Section.

B. Testing and Adjusting During and After Installation:

1. The testing and adjusting includes the submission of a test plan which shall describe in detail the method by which each component, subsystem, and system will be tested, calibrated, adjusted, and retested after installation in accordance with the specified sequences of operation and other characteristics of the control system. A report on test results, including set points and operating ranges of all components shall be submitted.

2. The testing specified in this paragraph shall not replace the testing specified in "Commissioning Tests and Verification" article of this Section.

C. Commissioning Testing and Verifications: The final phase of the quality assurance program of the project is the commissioning testing and verifications. This phase is to assure that the project is fully completed and that the systems are performing in accordance to specifications from end to end of the control systems. Demonstrations of the automatic control systems to the commissioning team in accordance to the requirements specified in Part 3 of this Section are required. A report on test results, including set points and operating ranges of all components, shall be submitted.

D. Testing: The testing phase of quality assurance includes the submission of a test plan which shall describe in detail the method by which each component, subsystem, and system will be tested, calibrated and retested after installation to perform in accordance with the specified sequences of operation and other characteristics of the control system.

E. Reporting and Demonstration: This phase shall include the submission of a written report describing the "actions taken during the testing" phase, and including the set points and operating ranges of all equipment and a demonstration that the system performs in accordance with contract requirements.

F. Operating Instructions and Training: This phase of quality assurance includes the training of operating personnel utilizing written operating instructions prepared and approved under the "Submittals" paragraph of this Section, and the mounting of laminated control diagrams where directed.

G. Maintenance Manuals: This phase includes the submission of all manufacturers' cuts, maintenance and operating instructions, test reports and demonstration

material, copies of control diagrams, and copies of the manufacturers' certifications. Two (2) CDs, DVDs, flash drives or other current electronic media device including the maintenance manuals shall be provided to the Owner (cloud storage is not an acceptable substitute). One (1) hard bound copy of the maintenance manual shall be provided to the Owner.

H. Contractor Qualifications: The control system shall be furnished, engineered, and installed by a licensed controls Contractor. The Contractor shall be regularly engaged in the service and installation of BACnet based systems as specified herein. The Contactor shall be experienced in the sales, installation, engineering, programming servicing and commissioning of the controls platform and the Bacnet field controllers as proposed.

1. The Contractor must be an authorized factory direct representative in good standing with the manufacturer of the proposed hardware and software components. Provide a letter dated within the last 6 months, from the manufacture certifying that the Contractor is an authorized factory direct representative.

2. The Contractor shall have an office within 75 miles of the Building site that is staffed with a minimum of two (2) technicians who have successfully completed the factory authorized training of the proposed manufactures hardware and software components and have successfully completed a certification course. The Contractor must provide proof of required training. The Contractor’s capabilities shall include engineering and design of control systems, programming, electrical installation of control systems, troubling shooting, and service.

3. The Contractor shall submit a list of no less than three (3) similar projects, which have similar Building Automation Systems as specified herein installed by the Contractor.

1.3 SUBMITTALS

A. Shop Drawings: For each system to be controlled, prepare a drawing which includes a system flow diagram, control diagram, sequence of operation and schedule of components. Control diagrams shall be complete with end-to-end connections of piping and wiring from component terminal.

B. Manufacturer's Data: For each manufactured device or subsystem submit manufacturers' specifications and printed photograph of the proposed device or subsystem. Include engineering descriptions, principle of operation and application, and proposed model, style or size clearly indicated.

C. Custom Reports: Not applicable for HVAC system.

D. Existing Sequences, Points, and Reports: Contractor shall submit for record.

1. Document all currently monitored and controlled points in the existing BAS.

2. Document all current custom reports and templates.

1.4 WARRANTY, SOFTWARE AGREEMENT, AND SERVICE AGREEMENT:

A. Warranty / Guarantee: The Control System shall be free from defects in workmanship and material under normal use and service. The Contractor shall furnish a guarantee covering all labor and materials furnished by him for a period of **two (2) years** from the date of final acceptance of his work, and he shall agree to repair and make good at his own expense any and all defects which may appear in his work during that time if such defects arise from defective workmanship and/or imperfect or inferior material.

1. The warranty shall extend to material that is supplied and installed by the Contractor. Material supplied but not installed by the Contractor shall be covered per the above to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation.

2. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.

B. Software Maintenance Agreement: Service maintenance agreements shall be excluded from this project scope. The Owner shall pursue the Service Agreement as a separate contract.

C. Software License Agreement: The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement but shall protect manufacturer's rights as it relates to disclosure of trade secrets contained within said software. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the BC, BAS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner.

1.5 SPARE PARTS / ATTIC STOCK:

A. Spare Attic Stock shall be EXCLUDED from bid pricing. Contractor shall review required spare parts & attic stock with Owner prior to project turnover.

2.1 MANUFACTURERS

A. Basis of Design Product: Subject to compliance with requirements, provide products by one of the following pre-qualified manufacturers:

1. Schneider Electric EcoStruxure Building BACnet series installed by approved manufacturer's local field office or authorized distributor.

2. Niagara Framework technology as developed by the Tridium Corporation. All tools and hardware provided shall comply with the current release of the Niagara 4 Framework platform.

2.2 INSTALLER AND SERVICE PROVIDER

A. The automatic temperature controls shall be furnished, installed, commissioned and warranted by one of the following acceptable providers:

1. A licensed provider for one of the BAS product manufacturers listed in section 2.1.

2. An approved manufacturer’s local office or authorized distributor for one of the BAS product manufacturers listed in section 2.1..

B. Manufacturers not listed above will not be acceptable.

2.3 SYSTEMS INTEGRATION

A. Control Loop Characteristics: Carefully evaluate the characteristics of each control loop, the time constants, equipment characteristics, control accuracy, and reliability and provide a system which will operate smoothly, without hunting, and within the accuracies specified.

B. System Components: Select components including sensors, transmitters, controllers, control devices, actuators, and instrumentation considering such factors as hysteresis, relaxation time, span, limits, and response time.

2.4 CONTROLLERS

A. General: Provide electric or electronic controllers for each local control loop.

1. Provide controllers with local adjustable setpoint, adjustable proportional band for analog controllers or adjustable differential for two position controllers.

2. Provide adjustable secondary input authority for dual input controllers with remote setpoint adjustment.

3. Provide integral or test connections for measuring input and output signal.

4. Controllers shall have a 10% spare point capacity or min. 1 point spare, whichever is greater.

B. Electric/Electronic System Characteristics: Provide a system of control which shall have all of the following system characteristics. Systems which do not conform to all of the following requirements will not be acceptable.

1. The system shall consist of multiple, field adjustable controllers. The controller, power supplies, input/output and other components specified, including metal cabinet will be referred to as a "Field Panel."

2. The field panel shall be capable of performing its assigned local loop control and other functions as a standalone unit. It shall perform all specified local loop control functions without interaction to other field panels, except for shared functions such as central time programs, heating-cooling changeover, etc.

3. The field panel shall utilize control algorithms that permit proportional, integral, and derivative control as required. Control algorithms shall permit one, two or three mode control as specified or indicated on the drawings.

4. Each field panel shall be capable of handling multiple control loops, with one or more controllers.

5. The system shall utilize industry standard sensors.

6. The field panel shall provide both analog and binary output control. Analog outputs shall be compatible with industry standard transducers. Provide a modulating analog output control signal. Binary output control commands shall be implemented through interposing control relays.

7. Field panels shall be of modular construction. The system shall utilize interchangeable components. The modular construction of the system shall permit quick repair, ease of expansion, and the use of standard controls.

8. Each field panel with sensors and controlled devices shall be capable of automatic, unattended restart in the event of electrical power failure. In the event of electrical power failure all controlled devices shall move to their predetermined "normal" positions. By normal, it is meant that spring-close valves shall close, spring-open devices shall open, spring return devices will return and magnetically held devices will move to the position dictated by the force of gravity. Upon the restoration of electrical power, the field panel shall automatically restart and provide control to its connected systems after power failures of up to 72 hours.

9. The field panel operating system shall reside in nonvolatile memory.

10. Site specific application data, setpoints and operator entered data shall be stored in volatile memory.

11. Nonvolatile memory shall include PROM, EPROM, EAROM, ROM and RAM.

12. The preceding terms describe a class of solid state semi-conductor memories manufactured with LSI (large-scale-integration) techniques. These terms are expanded as follows:

    a. PROM - Programmable Read Only Memory

    b. EPROM - Erasable PROM

    c. EAROM - Electrically Alterable ROM

    d. ROM - Read Only Memory

    e. RAM - Random Access Memory

13. Controller Loop – common zones: Equipment in "common zones / quads" shall be connected to controllers in the area they are serving. Contractor shall not connect equipment to controller simply based on "shortest run."

C. Field Panels: Provide field panels as follows.

1. Each field panel shall consist of a controller, power supplies, input/output modules, and other components specified.

2. Provide field panels where indicated. Provide additional controllers, if required, to support the control loops specified, the sequence of operations, number of monitoring points or other criteria to permit the field panel capacity to meet the specified functional requirements of the project.

3. Each field panel shall be capable of operation as a completely independent unit.

4. Each field panel or controller shall include its own means of adjustment on site by the operator.

5. Each field panel shall receive signals from industry standard sensors and input devices. Each panel shall have the capability to monitor the following types of inputs:

    a. Analog inputs: 4 to 20 mA and 0 to 10 V DC.

    b. Binary inputs: Dry contact closure and pulse accumulator.

    c. Provide transducers and/or signal conditioning to adapt other sensor types.

d. Field panels that permit the direct connection of resistance type sensors will be acceptable if the system accuracy, data resolution, value accuracy and sensor interchangeability, comply with all other requirements of the specification.

6. The field panel shall directly control actuators and control devices. Each field panel shall be able to provide the following control outputs:

   a. Binary outputs: Contact closure

   b. Analog outputs: 4 to 20 mA, 0 to 10 V DC and 0 to135 OHM.

   c. Systems that do not provide direct analog outputs will be acceptable providing that they generate the specified output signal through transducers.

7. Each field panel shall perform control functions and other routines, specified under Sequences of Operation.

8. Each field panel shall accept binary inputs, on-off, open-close, or other two state data. Provide isolation and protection against input voltage up to 180 VAC peak.

9. Each field panel shall provide Binary Output by contact closures for momentary and maintained operation of field devices. Provide electromagnetic interference suppression on all output lines to limit transients to non-damaging levels. Provide isolation and protection against voltage up to 180 VAC peak. Provide contacts rated for 2 A at 24 VAC.

10. Each field panel shall be enclosed in a metal cabinet. The cabinet shall be constructed of 16 US gauge sheet steel, Provide sufficient access for wire and conduit to enter the cabinet. The cabinet shall have a hinge door and a pin tumbler lock. All field panel locks for the project shall be keyed alike. The cabinet shall be shipped to the project for installation without electronics. The electronics shall be added at the time of wire termination and system commissioning. All control wiring and system communications shall be electrically terminated inside the field panel.

11. Provide a 20A duplex receptacle inside or immediately adjacent to the field panel. The receptacle shall be energized when power is disconnected from the field panel.

    a. Where the existing panels do not have an existing receptacle, the Contractor shall connect to the existing power circuit located within the room.

12. Ground the field panel and power supply with a minimum No. 12 THHN unbroken ground wire to the building earth ground system. There shall be a maximum of 5 ohms measured between the ground at the field panel and the building ground system.

13. Provide a master electrical power disconnect switch inside the field panel to disconnect all external power to the cabinet for maintenance and repair. The disconnect switch shall not affect the duplex receptacle hereinbefore specified.

14. Provide screw type terminal strips in the field panel for the termination of all field wiring. Lay out terminal strips in a neat and orderly fashion and label each termination. All wiring entering the panel shall be routed through the panel wireways in a neat and workmanlike manner, properly tied or laced and terminated.

15. Provide conduit and wire to connect the field panel to the nearest adequate source of normal power.

D. Wire/Cable Labeling: Label wire and cable as follows.

1. Label each cable and each conductor within 6 inches (150 mm) of the termination point. Cable and wire identification shall match the wiring identification shown on the installation and record drawings.

2. Wire identification labels shall be securely affixed to the wire and shall be of the preprinted type providing a durable vinyl or plastic covering over the printed lettering.

3. Wire identification through color coding, embossed label tape, paper tags attached with string and handwritten labeling will not be acceptable.

E. Transient Protection: Provide transient protection as required by the manufacturer.

F. System Accuracy: Provide system accuracy in accordance with the following.

1. Each local system shall maintain end-to-end accuracy for one year from sensor to controlled device for the applications specified.

2. Space temperature with a range of 50°F to 85°F (10°C to 29°C) plus or minus 0.75°F (.4°C) for conditioned space; 30°F to 130°F (-1°C to 54°C) plus or minus 1.0°F (.6°C) for unconditioned space.

3. Duct temperature with a range of 40°F to 140°F (4°C to 60°C) plus or minus 1.0°F (.6°C).

4. Outside air (OA) temperature with a range of minus 30°F to plus 130°F (minus -1°C to plus 54°C) plus or minus 2.0°F; with a subrange of plus 30°F to plus 100°F (plus -1°C to plus 38°C) plus or minus 1.0°F (.6°C).

5. Water temperature with a range of 33°F to 100°F (1°C to 38°C) plus or minus 0.75°F (.4°C); the range of 100°F to 250°F (38°C to 121°C) plus or minus 2.0°F (1.2°C); and water temperatures for the purpose of performing BTU calculations using differential temperatures to plus or minus 0.5°F (.3°C) using matched sensors.

6. High temperature water with a range of 0°F to 500°F (-18°C to 260°C) plus or minus 3.0°F (1.6°C).

7. Pressure with a range for the specific application plus or minus 2.0 percent of range.

8. Flow with a range for the specific application plus or minus 3.0 percent of range, and flows for the purpose of BTU calculations to plus or minus 2.0 percent of range.

G. Accuracy and Stability: Equipment shall be selected for the appropriate range of the application. Equipment selected with ranges in excess of the application will be replaced at the Contractor's expense.

H. Licensing for controllers: Refer to Section 1.4 for “Software License Agreement.”

2.5 SENSORS

A. General: Provide analog sensors for temperature controllers. Provide sensors with an output signal that varies continuously with the sensed temperature, within a specified range, of the thermistor or resistance type.

B. Manufacturer: Temperature sensors shall be made by one manufacturer.

C. Space Sensors: Provide space or room sensors with base plates thru-bolted into masonry or wall studs, brushed cast aluminum or 16 gauge (1.6 mm) ground and polished Type 316 stainless steel covers.

D. Insertion Type: Stem or extended surface sensitive type with screw mounting plate and galvanized sheet steel insulation mounting box.

E. Immersion Type: Stem or tip sensitive type with threaded immersion well base.

F. Sensing Elements: Hermetically seal, except for bimetal type for room thermostats. Stem, tip or extended element shall be Type 304 stainless steel or annealed copper.

G. Casing: Casing shall be constructed of watertight, vibration-proof, heat resistant high strength phenolic or 316 stainless steel.

H. Sensor Wells: Provide 304 stainless steel, bronze, copper or monel machined wells, compatible with the immersion medium, and heat sensitive transfer material or liquid between sensor and well surface.

2.6 ELECTRONIC ANALOG SENSORS

A. Range: Sensors shall operate within the range of minus 30°F to plus 220°F (minus -34°C to plus 104°C) for heating, ventilating and air conditioning (HVAC) systems.

B. High Temperature Sensors: For high temperature water applications provide sensors with a range of 0°F to 500°F (-18°C to 260°C).

C. Accuracy: Provide electronic analog sensors with an accuracy of plus or minus 0.25°F (.14°C).

D. Time Constant Response: Provide sensors with a time constant response to achieve 60 percent of a step temperature change in six (6) seconds in air or water flowing at 3 feet per second (.9 m/s).

E. Interchangeability: Sensors of the same type shall be interchangeable without calibration.

2.7 PRESSURE SENSORS

A. Overpressure Protection: Provide pressure sensors impervious to instantaneous pressure changes of 150 percent of working pressure but not less than plus or minus 50 psig (340 kPa).

B. Adjustment: Provide sensors with external adjustable span, adjustable zero and pulsation suppression.

C. Finished Spaces: Conceal pressure sensors in recessed stainless steel housing with removable perforated brushed stainless steel cover.

D. Sensor Characteristics: Provide pressure sensors with the following characteristics:

1. Ambient Temperature: 40°F to 140°F (4°C to 60°C).

2. Isolation Valves: Provide pressure sensors with stainless steel needle isolation valves between each sensor and sensor pressure source. Provide differential pressure sensors with 3-valve manifold for isolation and nulling.

3. Siphon: On steam systems provide pressure sensors with a pigtail siphon between the sensor isolation valve and sensor. Provide condensate wells and blowdown valves for differential pressure sensors.

4. Provide switching type sensors with platinum alloy, silver alloy or gold plated wiping contacts rated for the application, voltage and power levels.

5. Provide valved calibration taps adjacent to each pressure sensor for calibration.

2.8 STATIC PRESSURE ANALOG SENSORS

A. Types: Provide diaphragm sensors with solid state pre-amplifier electronic systems.

B. Characteristics: Provide analog sensors with the following characteristics:

1. Sensor span shall be not less than 150 percent and not more than 300 percent of the working pressure.

2. Accuracy shall be 0.5 percent of calibrated span including combined effects of linearity, hysteresis and repeatability.

2.9 DIFFERENTIAL PRESSURE ANALOG SENSORS

A. Types: Provide differential pressure analog sensors of the solid state pre-amplifier types for electronic systems.

B. Characteristics: Provide sensors with the following characteristics:

1. Sensor span not less than 150 percent nor more than 300 percent of the working differential pressure.

2. Accuracy of 0.5 percent of calibrated span, including combined effects of linearity, hysteresis and repeatability.

3. Pressure sensor shall withstand overpressure of not less than 200 percent working pressure and full vacuum underpressure without damage, changes in sensor accuracy or deformation.

2.10 DEW POINT AND RELATIVE HUMIDITY SENSORS

A. Dew Point Sensors: Provide analog salt-phase transition or dual cooled mirror type sensors with an accuracy of plus or minus 3°F (1.6°C) dew point over the range of 10°F to 100°F (-12°C to 38°C) dew point.

B. Relative Humidity Sensors: Provide analog precision resistance or hydro-mechanical gauge type relative humidity sensors, with an accuracy of plus or minus 2 percent of relative humidity over a range of 10 to 90 percent relative humidity.

C. Shields: Provide 316 stainless steel weatherhoods and shields to protect outdoor sensors from sunlight, snow, ice, wind and rain and provide fan powered aspirator complete with wiring if recommended by the manufacturer.

D. Indoor Covers: Sensors located in public spaces shall have brushed 16 gauge (1.6 mm) 316 stainless steel covers or recessed aspirating boxes with Allen head screw mounting plate.

2.11 THERMOSTATS

A. Types: Provide electronic thermostats which operate in an analog proportional or binary two-position mode as required by the sequence of operation.

B. Mounting: Mount thermostats in non-public spaces except room thermostats.

C. Electric Analog Thermostats: Provide electric analog thermostat with the following characteristics:

1. Sensor shall be of the bulb or capillary type which shall actuate a 135 ohm 3-wire potentiometer for 0-10 VDC, or 4-20 milliamp proportioning control action of balanced bridge motor actuators.

2. Sensor shall have adjustable setpoint range of not less than 80°F (27°C) throughout the range of 0°F to plus 250°F (-18°C to plus 121°C).

3. Adjustable proportional band ranges from 3°F to 25°F (-16°C to -4°C) and capillary length of not less than 5 feet (1500 mm) shall be provided.

D. Electric Two Position Duct and Immersion Thermostats: Provide thermostats with bimetal or bulb and capillary type sensor actuating one or more switching contacts.

1. Contact shall be rated for the imposed load or shall be a pilot duty type and provided with a control relay.

2. Thermostats shall have adjustable setpoint throughout the range 0°F to plus 250°F (-18°C to plus 124°C).

3. Fixed differential thermostats with differentials of 3 may be provided for On-Off control of unit heaters, ventilating fans and similar applications.

4. Provide capillary tubes in the 5 to 20 feet (1500 to 6000 mm) lengths to suit applications.

E. Freeze Protection Thermostats: Electric freeze protection thermostats shall be provided with capillary elements, and special purpose insertion elements not less than 20 feet (6000 mm) in length for the face of coils up to 80 square feet (7.4 m^2). Freeze protection thermostats shall have the following characteristics:

1. A freezing condition at any one foot length increment anywhere along the sensing element shall activate the thermostatic switch.

2. Switch shall require manual reset.

F. Weather Shields: Provide weather shields and outside air sensing elements with the following characteristics:

1. Mount elements and shields on the north face of the building or location out of direct sunlight.

2. Construct shields of 16 gauge (1.6 mm) 316 stainless steel with flanges bolted to a backplate with not less than four 1/4-inch (6 mm) diameter stainless steel bolts. Mount backplate to the building structure with expansion bolts.

3. Construct shields to inhibit solar effects. Construct shields in a rectangular box configuration with ventilating raintight louvers to preclude the entrance of snow, ice and rain. Design for crossflow and vertical air circulation.

4. Mount shields accessible for maintenance.

5. Seal wall penetration watertight.

2.12 SPACE THERMOSTAT (NETWORK ENABLED)

A. Occupied spaces shall be provided with DDC network enabled, communicating, zoning thermostats. Shall have: user touchscreen display, temperature setpoint and occupancy override; and CO2, RH, and Temperature.

1. Provide SmartX Living Space Sensor / Zone Controller or equivalent to match thermostats installed in the OPACY Warehouse, example model #s below.

a. Model SXWSCDXSELXX for sequences not requiring occupancy sensors

b. Model SXWSCDPSELXX for all office areas, conference rooms, and sequences requiring occupancy sensors.

2.13 PRESSURE CONTROLLERS

A. Types: Provide electric electronic pressure controllers of the analog or two-position type as required by the sequence of operation.

B. Analog Controllers: Provide controllers with proportional action plus integral and derivative control modes.

1. Provide sensing elements of the differential type measuring controlled medium and standard reference pressures.

2. Air static pressure controllers shall have slack diaphragms with standard ranges 0 to 6 inches water column (0 to 1500 Pa) and an adjustable proportional band range of 0.02 to 0.5 inches water column (5 to 125 Pa).

3. Sensing elements for duct applications shall be damped to preclude pulsation.

4. Water differential pressure controllers shall have a minimum range of 0 to 50 psig (0 to 345 kPa) or 0 to 250 psig (0 to 1725 kPa) as required by the application with adjustable proportional band of one to 25 psig (170 kPa). Sensing elements shall be diaphragm type with 3-valve manifold. Provide siphons and pressure snubbers.

2.14 ELECTRIC PRESSURE SWITCHES

A. Type: Provide bourdon tube or diaphragm type electric pressure switches with tamperproof adjustable set point and differential settings. Design switches for 200 percent overpressure and full vacuum underpressure without damage or accuracy impairment.

2.15 AUTOMATIC DAMPERS (Not used, see General Scope Section below)

A. General Scope: Damper replacement not included in base scope, only actuators are. However, if a damper is found to require replacement, the contractor shall provide submit an RFI for Owner and Engineer review. If damper replacement is approved, the following damper section shall be applicable.

B. Standards: Provide opposed blade and parallel blade factory fabricated dampers of extruded aluminum, galvanized steel or stainless steel with metallic anti-friction non-ferrous bearing in accordance with Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) standards.

C. Types: Use parallel blade dampers in mixing chambers and plenums. Use opposed blade dampers for volume control, face and bypass dampers, smoke dampers, fan discharge, and variable air volume control.

D. Pressure Rating: For fan systems less than 10-inch water gauge (2490 Pa) static pressure, design and construct dampers to withstand a pressure of 150 pounds per square foot (7.1 kPa) without damage, leakage, flexure, or distortion.

E. Leakage: Maximum air leakage rate for all dampers shall not exceed 10 cubic feet of air per minute per square foot (50 L/s/m^2) at atmospheric pressure when closed against a 4-inch water gauge (1000 Pa) static pressure.

F. Operators: Damper operators shall have sufficient power to open and close the dampers and limit the leakage to the specified rate. Power wiring shall be extended to operator by this contractor.

G. Shafts and Bearings: Provide cadmium plated steel shafts in permanently lubricated bronze sleeve bearings or permanently lubricated ball bearings.

H. Blade Sizes: Reinforced or ribbed blades shall not exceed 8 inches (200 mm) in width nor 48 inches (1200 mm) in length.

1. Flat or unreinforced blades will not be acceptable.

2. Damper sections exceeding 4 feet (1200 mm) in width or 4 feet (1200 mm) in height shall be constructed with multiple frames and linkages.

I. Frames: Construct frames of factory welded galvanized steel hot dipped after construction or bolted extruded aluminum frames.

1. Dampers larger than 8 square feet (.7 m^2) in area shall have corner bracing gussets at each corner welded to the damper frame.

J. Linkages: Provide linkages to uniformly transmit damper operating forces to each damper blade.

1. Construct linkages of galvanized or cadmium plated steel or stainless steel.

2. Bearings and joints shall be ball and socket or sleeve bearings of brass, bronze or stainless steel, with plated bolts and locking nuts.

K. Seals: Provide mechanically attached elastomer or neoprene blade tip seal along the full length of each blade edge and flexible stainless steel seals along damper blade ends where the blades abut the frame. Adhesives or staples will not be acceptable.

L. Damper Mounting: Mount dampers to casings and ductwork in conformance with SMACNA standards. Provide welded or bolted galvanized steel structural supports for dampers larger than 20 square feet (1.9 m^2). Through bolt damper frames to structural supports.

2.16 AUTOMATIC VALVES

A. Standards: For chilled water, low temperature hot water and low pressure steam provide valves conforming to ANSI B16.15, "Cast Bronze Threaded Fittings," Class 125 copper bearing steel, bronze, or ANSI B16.1, "Cast Iron Pipe Flanges and Flanged Fittings," Class 125 cast iron. For high temperature water, steam above 25 pounds per square inch (170 kPa) and water above 100 pounds per square inch (690 kPa) provide valves conforming to ANSI B16.5, "Pipe Flanges and Flanged Fittings," cast steel or stainless steel. Select valve pressure class minimum 150 percent of maximum working pressure.

B. End Connections: Provide valves with end connections as follows:

1. For chilled water, low temperature hot water and low pressure steam provide valves with flanged connections on sizes 2-1/2 inches (65 mm) and larger and threaded connections on valves 2 inches (50 mm) and smaller.

2. For high pressure steam provide flange or union connections on valves 1-1/2-inch (40 mm) and larger.

C. Small Water Valves (1” and Smaller): For valves controlling low pressure and low temperature chilled or hot water sizes one inch and smaller, bodies shall be bronze, cast iron or stainless steel with screwed, union or flare connections.

D. Valve Trim: Provide valve trim as follows:

1. Stems shall be 316 stainless steel.

2. Disk and stuffing boxes may be bronze or 316 stainless steel.

3. For all valves 1-1/2-inch (40 mm) and larger, stems, disks, and seats shall be 316 stainless steel.

4. All non-metallic parts of hot water and steam valves shall be designed for minimum 250°F (121°C) or 100°F (38°C) above system design temperature.

5. Leakage: Control valves shall provide tight shut off in the closed position at 150 percent of maximum working pressure.

E. Valve Characteristics: Select valves to provide equal percentage control of water and linear control of steam. Modulating valves for steam shall have V-port skirts, tapered plugs for water.

1. Butterfly valves that do not have “equal flow characteristics” will not be acceptable for modulating control.

2. For two-position, water application action, butterfly valves may be used, provided the differential pressure across the valve does not exceed 25 pounds per square inch (170 kPa).

F. Sizing: Provide valves of sizes indicated, or as herein specified.

1. Size steam valves with a pressure drop not to exceed 50 percent of the total differential between supply and return main at full indicated flow.

2. Size water valves with a maximum differential pressure not greater 10 feet (480 Pa) or 1/2 the loss through the controlled apparatus, whichever is greater.

G. Actuators: Provide actuators, sized by the manufacturer, of sufficient size and power to operate the valve under all conditions and to close the valve tight against maximum differential pressure.

1. Provide pilots for sequence operations, and cases where valve spring ranges have been increased to close off against system pressure.

2. Comply with requirements of "Actuators" paragraph of this Section.

2.17 ELECTRIC ACTUATORS

A. General: Provide electric motor driven actuators (operators) arranged "Fail Safe" in the event of power failure. Unless indicated otherwise, the fail position of each cooling coil valve shall be the “last position” or “current position” at the time of failure and the fail position of each heating valve shall be “full open”. Design operators to be quiet in operation and function within a range 85 to 100 percent input power potential.

B. Electric Actuators: Provide hydraulic or gear type electric actuators.

1. When operated at rated voltage each actuator shall deliver the torque required for continuous uniform movement of the control device from limit to limit.

2. Provide an end switch to limit travel and design the actuator to continuously stroke without damage.

3. Operators shall function properly within a range of 85 to 120 percent of line voltage. For actuators with input power greater than 100 watts, gears shall be ground steel, oil immersed, shaft shall be hardened steel running in bronze, copper alloy or ball bearing and operator and gear trains shall be totally enclosed in dustproof cast iron, cast steel or cast aluminum housing.

4. Actuators with input power less than 100 watts may use fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings and pressed steel enclosures.

5. Two position actuators shall be of the single direction, spring return or reversing type.

6. Proportioning operators shall be capable of stopping at all points in the cycle and starting in either direction from any point.

7. Reversing and proportioning operators shall have limit switches to limit travel in either direction.

C. Damper Operator Mounting: Mount damper operators where accessible for maintenance.

1. If located outside the duct or casing, mount operators on a 14 gauge (2.0 mm) reinforced support plate arranged to allow insulation between the support plate and the face of the duct or casing.

2. Brace damper operators rigid to show no deflection or movement over the full range of the damper stroke.

2.18 CONTROL PANELS AND CABINETS

A. Local Panels and Cabinets: Provide local control cabinets for each air handling unit, automatically controlled equipment such as pumps, fans, heaters and convertors, or groups of such equipment in a single mechanical equipment room.

B. Standards: Construct panels in conformance with UL 50, "Cabinets and Boxes," or similar approved construction, with backbox, full-sized piano hinged face, stainless steel lockable latch, and secure to the building construction.

1. Internally mount all controllers, relays, terminal boards, and miscellaneous control devices, on a removable panel.

2. Flush mount in the door all indicators, selector switches, remote setpoint adjusters, and pilot lights.

3. Cabinet internals may be factory or field wired and piped. Wire shall be neat, braced, and strapped flat to present a neat appearance and to easily trace wiring and piping from one device to another.

4. Floor mounted panels shall be bolted to 1-1/2-inch by 1-1/2-inch (40 mm by 40 mm) structural support channel, bolted to the floor and braced at the top.

2.19 SYSTEM DIAGRAMS

A. Mounting: Mount control diagrams adjacent to each local control panel on a furniture steel extension either bolted to wall or to an extension of the control cabinet structural support.

1. Control diagrams shall include system one-line diagram, system control diagram, sequence of operations, and schedule of control devices.

2. Diagrams shall be hermetically sealed in laminated 16 gauge (1.6 mm) plastic.

3. Diagrams shall be permanent, black on white background, not subject to fading when subjected to artificial or natural light. Diazo prints are not acceptable.

4. Diagrams shall represent the current, "as-built" status of the control system, after acceptance by the representative of the Owner.

5. Obsolete, out of date, or field modified diagrams shall be removed, and new current diagrams furnished.

6. Diagrams and devices on local control panels shall be identified with engraved phenolic nameplates, white on black, minimum 1/4-inch (6 mm) high block capital lettering, screwed or bolted to panel or mounting plate face. Adhesive attachments are not acceptable.

2.20 WIRING

A. General: Provide a complete system of electric wiring for temperature control apparatus including control power transformers and wiring to the transformer primary.

B. All wiring within Mechanical Rooms, Service Level, and where exposed to view shall be installed in conduit. All ATC wiring shall be plenum rated. Refer to Division-26 section, “Raceways.” MC cable is prohibited in all locations.

C. Wiring: Wire for low voltage AC shall be minimum 300 volt insulated copper No. 18 AWG or larger conforming to NFPA 70, Type MTW, THHN or TFFN, installed in accordance with Division-26 of these specifications.

1. For low voltage DC and an electronic circuit carrying less than 0.5 amperes, cables of two or more conductors not smaller than No. 18 AWG solid copper or No. 18 AWG solid copper if not shielded may be used in lieu of individual wires.

2. Cables carrying analog signals shall be shielded, if required by the manufacturer.

3. Cables shall be terminated in solder or screw type terminal strips.

4. Cables shall not be tapped at any intermediate points.

5. All wire shall be color coded or numbered for identification. Identify as indicated on shop drawings and "as-built" drawings.

6. Wire terminating in screw type terminal strips shall have pressure connectors conforming to UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," or UL 486B, "Wire Connectors for Use with Aluminum Conductors."

7. Wire terminations without connectors or traveling pressure pads will not be accepted.

D. Network Cable shall be CAT 6 and “Orange”. Network cable shall be provided from ATC panels to unit controllers”.

E. The contractor shall in no case combine control wiring (line or low voltage) with power wiring in the same conduit.

2.21 OPERATOR WORKSTATIONS, SERVERS, ACCESSORIES, AND GRAPHICS

A. Provide two (2) PC based operator’s workstations within the building at a locations determined by the owner, including a flat screen monitor (minimum 21”) and a color laser printer. Provide color graphics of all systems to be controlled, monitored and alarmed by the EMCS. Computer hardware and software shall be compatible with the most current version of the ATC vendor’s software and graphics packages.

B. Provide a portable operating terminal for connection to the main DDC control panel. In addition, main panel shall be provided with modem connection.

C. Provide a physical Enterprise Level Server for the BAS and a redundant Server for backup. The redundant Server can be a physical Server or a web-based Server. Physical Servers shall be located where indicated on the drawings or locations determined by the building owner. Computer hardware and software shall be

compatible with the most current version of the ATC vendor's software and graphics packages.

D. User Interface:

1. The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

2. System shall be able to automatically switch between displayed metric vs. imperial units based on the workstation/webstations localization. (Default is imperial units).

3. Personalized layouts and panels within workstations shall be extended to webstations to ensure consistent user experiences between the two user interfaces.

4. Webstations shall give the user the same capabilities within the graphics pages as are given within the workstation but shall be mobile responsive for use on smaller devices.

5. Workstation shall indicate at all times the communication status between it and the server.

6. The BMS web interface shall enable presentation mode whereby any functionality for interactivity shall be disabled.

7. The BMS web interface shall support full screen mode displaying Alarm views / graphics / dashboards / Custom Reports.

E. User Access and Permissions

1. The BMS system shall allow for creation of one account per user.

2. The BMS shall support Groups where User Accounts associated with the group can inherit group permissions.

3. The BMS shall be able to specify each user account / group accessibility to each object in the system.

4. The BMS permission system shall be possible to integrate with Windows Active directory.

5. The BMS shall be able to report on the permission level across account / group for review / archiving / audit.

6. This username/password combination shall be linked to a set of capabilities within the software, set and editable only by user with system administrator privileges. The sets of capabilities shall include: edit or View only, Acknowledge alarms, Enable/disable Program and change values.

F. Configuration Interface

1. The workstation software shall provide an interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure.

2. The configuration interface shall also include support for user defined object types. These object types shall be used as building blocks for the creation of the BAS database. They shall be created form the base object types within the system input, output, string variables, setpoints, etc., alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of user defined object types shall be able to be set up as a predefined aggregate of subsystems and systems. The configuration interface shall support copying/pasting and exporting/importing portions of the database for additional efficiency. The system shall also maintain a link to all "child" objects created. If a user wishes to make a change to a parent object, the software shall ask the user if he/she wants to update all of the child objects with the change.

G. Color Graphic Displays

1. The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.

2. Requirements of the color graphic subsystem include:

a. At a minimum, the user shall have the ability to import .gif, .png, .bmp, .jpeg, .tif, and CAD generated picture files as background displays, and layering shall be possible.

b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, ad graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.

c. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.

d. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.

e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

f. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.

g. Graphics should rescale based on whatever monitor or viewing device is being used.

h. Be able to create graphics within varying window panes that can be moved and/or re-referenced. For example, creating the graphical menu within a pane and referencing it on every graphics page, therefore not rebuilding thus allowing for a single spot for updates that get pushed to all the pages that reference it.

i. The ability to create re-usable cascading menus.

j. The ability to have multiple instances of a graphic and edit one instance to change all.

H. The software shall allow for the automatic collection of data and reporting from any controller or NSC. The frequency of data collection shall be user-configurable.

I. Alarm Management

1. The software shall be capable of accepting alarms directly from the server or controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.

2. Alarm management features shall include:

a. Each notification level will establish a unique set of parameters for controlling alarm display, distribution, acknowledgment, keyboard annunciation, and record keeping.

b. It shall be possible for the user to sort, filter and search on any available criteria such as priority, category, origin, alarm type, etc.

c. An active alarm viewer shall be included which can be customized for each user or user type to a hide or display any alarm attributes.

d. It shall be possible to present alarms with configurable colors based on priority, category, origin, alarm type, etc.

e. Automatic logging in the database of the alarm message, point name, point value, source device, timestamp of alarm, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement).

f. Alarm notifications must support multiple distribution methods within one notification

g. On alarm, it shall be possible to notify via email to a preconfigured list of recipients . through a Simple Mail Transfer Protocol (SMTP) or secure email using Simple Mail Transfer Protocol Secure (SMTPS). No special software interfaces shall be required and no email client software must be running in order for email to be distributed. The email notification shall be able to be sent to an individual user or a user group.

h. An operator shall have the capability to assign an alarm to another user of the system.

i. Individual alarms shall be able to be assigned to a user automatically via a preconfigured list of users and date/time.

j. The active alarm viewer can be configured such that an operator must confirm that all of the steps in a check list have been accomplished prior to acknowledging the alarm.

J. Scheduling

1. From the workstation or webstation, it shall be possible to configure and download schedules for any of the controllers on the network.

2. Time of day schedules shall be in a calendar style and viewable in both a graphical and tabular view.

3. Schedules shall be programmable for a minimum of one year in advance.

4. To change the schedule for a particular day, a user shall simply select the day and make the desired modifications.

5. Additionally, from the operator webstations, each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

6. Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

7. It shall be possible to assign a lead schedule such that shadow/local schedules are updated based upon changes in the Lead.

8. It shall be possible to assign a list(s) of exception event days, dates, date ranges to a schedule.

9. It shall be possible to view combined views showing the calendar and all prioritized exemptions on one screen.

10. It should accommodate a minimum of 16 priority levels.

11. Values should be able to be controlled directly from a schedule, without the need for special program logic.

12. It shall be possible to share schedules between multiple integrated systems. For example, a common schedule shall be able to control HVAC equipment and lighting.

2.22 FLOW SENSORS

A. General: Provide sensors for measuring flow in piping and ductwork that are compatible with static pressure and differential pressure analog of the electronic controllers served.

B. Turndown: Provide sensors with an output characteristic which gives a continuous mathematical function over the full range of flow from maximum to minimum required.

C. See specifications, this section, for required air and/or water flow monitor measurement characteristics.

D. Provide all necessary power and control wiring as required for complete and operational flow measurement systems interlocked with the building EMCS.

2.23 AIRFLOW MEASUREMENT SYSTEMS (AIRFLOW MONITORS)

A. The airflow measurement system (AFMS), including airflow monitor, sensors, controllers, transmitters, etc., indicated on the plans shall be capable of continuously monitoring airflow rates at each measurement location. The system shall consist of one or more airflow measuring devices and a single microprocessor based transmitter. The number of sensing points shall be as per manufacturer's recommendation for the specified application. The AFMS shall not require recalibration or adjustment over the life of the equipment. If the technology provided is vortex shedding or the pitot tube type the system shall be calibrated on a semi-annual basis during the construction phase through the end of the warranty. The manufacturer is responsible for all cost associated with recalibration.

B. Upon request, the manufacturer shall provide for approval and verification a written copy of the following:

1. 16 point NIST traceable report of calibration used for the reference standard.

2. UL/cUL 873 report listing the AFMS as a complete assembly.

3. Independent laboratory test report results of 100% survival rate in a 30 day saltwater and acid vapor test.

C. The AFMS shall produce a single, linear, analog output signal for airflow, which can be measured by the host control system. The system shall have the ability to perform self-diagnostics and automatic zeroing to adjust the signal to zero at pre-determined time intervals, which eliminates all output signal drift due to thermal, electronic and mechanical effects. In the event of sensor failure, the system shall ignore the failed sensor(s), average the remaining sensors and continue to operate.

D. The total accuracy from the airflow measurement to the host controls, including sensing point averaging error, the sum of the sensor and electronic (transmitter) errors, etc. shall not exceed +/-2% of reading at both minimum and maximum airflow rates based on the manufacturer's published performance specifications for all devices. In addition, total system performance including sampling error, shall not exceed +/-5% of actual airflow. The installed accuracy, in accordance with manufacturer's recommendations, without field adjustment shall be as follows throughout the operating range:

1. Ducts and plenums: +/- 3% of reading

2. Outside air intakes: +/-5% of reading

3. Fan inlets: +/- 10% of reading

E. The sensors and electronics shall operate over a temperature range of -20 to 120°F for ducted supply or return applications and -20 to 120°F for outside air applications. The sensors and electronics shall operate at a relative humidity range of 0 to 95% (non-condensing) for ducted supply and return applications and 0-99%

(non-condensing) for outside air applications. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of ±2% of reading over the entire calibrated airflow range of 0 to 5,000 FPM for ducted applications. Upon request, a working demos shall be provided to the design team to display that the system can work at low flows.

F. For standard applications, sensors shall be constructed of materials that resist corrosion due to moisture or salt in the airstream. Aluminum probes shall be provided. For laboratory exhaust applications, provide stainless steel sensors with stainless steel casing. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/2CL2P, UL/cUL listed cable rated for exposures from -67°F to 392°F (-55°C to 200°C) and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable. Devices that have electronic signal processing components on or in the sensor probe are not acceptable. Where the electronics are installed in a location exposed to potential wind driven rain or snow (including outside air plenum) provide a NEMA 4 enclosure for all electronics. In addition, a visual display shall be provided to illustrate airflow (CFM) and temperature. The transmitter must also be able to display individual sensor reading and each individual flow for each fan on a fan array.

G. Analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate; while the second output (AO2) shall be field configurable to provide one of the following: temperature, low and/or high airflow user-defined set point alarm, individual fan alarm (for fan arrays) or system status alarm.

H. Airflow measuring devices shall be UL listed as an entire assembly. The transmitter shall include fused protection.

I. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans for conformance with installed accuracy requirements. A written report shall be submitted to the consulting mechanical engineer if any measurement locations will not result in specified installed accuracy requirements.

J. Prior to purchase or installation of the air flow monitor (AFM), the Contractor and/or AFM Product Representative shall review each equipment and/or duct mounted location to verify suitability for installation. Should there be any discrepancy regarding installation or performance, the Contractor shall notify the Engineer immediately.

K. Provide all necessary power and control wiring as required for a complete and operational air flow measurement system interlocked with the building EMCS. Network communications RS 485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, high and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates (individual fan airflow rates for fan arrays) and individual sensor node temperatures.

L. Airflow measurement system manufacturers shall be limited to the following:

1. Ebtron (Gold)

2. Air Monitor Valo-probe with Veltron II transmitter

3. Tek Aire Vortek VT-5000

2.24 FLOW METER

A. Flow meters are not required in current project scope.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring and Conduit: Provide wiring and conduit to connect the automatic control system components for an operational system.

1. Provide wiring in accordance with requirements indicated in this section.

2. Run conduit in straight lines, parallel to the lines of the building, and rack on factory furnished mounting blocks attached to the building structure. Where run buried in slabs provide long sweep rigid conduit bends extending 6 inches (150 mm) above the slab at slab penetrations.

3. Do not bury or conceal wiring beneath building insulation.

4. Locate wiring clear of access doors, accessible ceilings, lighting fixtures, walkways, or any location subject to damage or abrasion.

5. Existing conduit may be reused if in good condition and will not cause conflict with phasing of work.

B. Identification: Label or code each field wire at each end, and each controller and controlled device.

1. Identification shall be permanent, robust, not subject to fading, and flameproof.

2. Permanently mark terminal blocks at wire termination points.

3. Identify each control device with an engraved laminated phenolic nameplate, white on black, lettering not less than 1/8-inch (3 mm) height, on 1-1/2-inch (40 mm) by 1-inch (25 mm) tag and brass interlocked chain secured to the control device. Name shall correspond with identification on the shop drawings.

4. Identify sensors, controllers, relays, either mounted in local or central control panels, or remote mounted with a similar name tag as specified above. Attach to or adjacent to controllers with stainless steel or brass

screws or rivets. Adhesives will not be acceptable. Do not attach to removable controller covers.

C. Pipe Work: Mount strap-on sensors using helical screw stainless steel band clamp for strap-on thermostats, aquastats and other temperature switches on new piping for unit heaters and fan coil units after the pipe is cleaned to bright metal. Strap-on sensor may be used on piping up to 2-1/2-inch (65 mm) diameter. On pipe 3 inches (80 mm) and larger use pipe wells.

D. Pipe Wells: Install pipe wells above the horizontal to retain liquid heat transfer fluid in the well.

E. Valves: Install valves in piping with stems as vertical as possible but in no case less than 45 degrees from vertical. For soldered or welded connections, remove valve internals before mounting.

F. Electric Valves: Wire electric valves in accordance with NFPA 70 with not less than 2 feet (610 mm) of flexible liquidtight connector with watertight bushings at the valve actuator. Brace conduit to the building structure.

G. Pressure and Temperature Sensors: Install pressure and temperature sensors as follows.

1. Locate pressure and temperature sensing points sufficiently downstream from the control device to increase control loop time constant and minimize hunting.

2. Locate shut-off valves and 3-valve bypasses as specified in "Sensors" paragraph of this Section.

3. Locate sensors where accessible for maintenance and replacement.

4. Do not cover or conceal sensors with insulation.

H. Space Sensors: Install space sensors as follows.

1. Provide space thermostat with digital display in all occupied spaces. Thermostat adjustment shall be set and locked-out through the BAS (default).

2. Locate room thermostats and other room sensors approximately 48 inches (1200 mm) above the floor (or otherwise as required to meet the most current ADA guidelines) on inside wall where they will respond to average conditions in the space. All locations shall be field verified and coordinated with owner.

3. Sensors mounted on outside walls, if unavoidable, shall be mounted on factory made insulated brushed stainless steel bases.

4. Provide thermostat/sensor guards (total quantity of 15) where directed by the owner. Thermostat/sensor guards shall be clear, impact resistant lockable plastic or approved equivalent.

I. Air Handling Unit Temperature Indicators: For each factory assembled central station air handling unit and field erected air handling unit, provide temperature indicators in the following locations.

1. Each outside air plenum.

2. Each return air plenum.

3. Each cooling coil inlet and discharge.

4. Each heating coil discharge.

5. Temperature indicators shall be so located that they may be read by an operator standing on the operator floor. Indicators more than 8 feet (2400 mm) above the floor shall be remote bulb type.

J. Duct Sensors: Select duct sensor locations to properly sense average air conditions, minimize vibration, avoid dead air spaces, and within velocity limits required by the manufacturer.

1. Provide velocity shields where required.

2. Securely mount or clamp averaging elements, maximum 3 feet (900 mm) on centers to the leaving side of coils and equipment. Insulate averaging elements from equipment and protect from vibration.

3. Provide separate duct flanges for each sensing device.

4. Provide gaskets or sealant where elements penetrate duct walls.

5. Mount sensor to allow easy removal and servicing without disturbing insulation or vapor barrier. Mount on standoff brackets to avoid condensation.

6. Coordinate the location for duct access doors downstream from each duct sensor.

K. Pipe Sensors: Provide wells for all sensors and indicators measuring temperatures in pressure vessels and piping.

1. Wells shall be stainless steel or bronze to match media requirements.

2. Verify working pressure of sensor wells.

3. Do not install wells in extension couplings.

4. Where pipe diameters are smaller than the well length, provide wells at piping elbow or tees to affect flow across the entire well area.

5. Wells may face upstream or downstream.

6. Angle wells to retain thermal fluid within the well.

7. Should wells restrict cross sectional pipe area to less than 70 percent free area, provide pipe increases at the well not less than 150 percent pipe diameter.

L. The ATC contractor shall interface with smoke detectors, smoke dampers and fire alarm devices as required to accomplish equipment shutdown, alarms, etc., as indicated in sequences.

M. For single phase motors, provide relays and/or contactors of appropriate horsepower and voltage rating as required to energize/de-energize equipment as indicated in sequences.

3.2 TEST PLAN

A. Test Plan: Prepare a written test plan indicating in a step-by-step, logical fashion, the procedures by which the automatic control system will be tested, adjusted, and checked.

B. Pre-Approval: Not less than six (6) weeks prior to testing, provide four (4) copies of the proposed test plan for approval. Meet and discuss the test plan, and make agreed changes to the written plan.

C. Content: Plan shall include, as a minimum, for each system and sub-system of the automatic control work the following:

1. System name.

2. List of devices with brief description of functional purpose of each.

3. A description of the expected signal values transmitted by the sensor.

4. A description of the expected signal values transmitted by the controller to the control device or actuator.

5. A description of the expected values of the control medium from limit-to-limit.

6. A description of the instrumentation required to test the system.

7. A description of the expected field adjustments for transmitter, controller, and control actuator should control parameters fall outside of expected values.

8. A log sheet or sheets on which expected and field read values will be recorded and final field read values indicating that the system is operating in accordance with contract requirements.

3.3 TESTS DURING AND AFTER INSTALLATION

A. Instrumentation and Control: Calibration test each controller as follows:

1. Disconnect the sensor input signal to the controller and provide a compatible test signal generator.

2. Simulate expected transmitter values and input to the controller. Record controller branch line values.

3. Examine control device and determine that the device is responding.

4. Simulate maximum and minimum transmitter signal values and verify minimum and maximum controller output values and control device minimum and maximum stroke range.

5. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedule, proportional relationship, reset relationship, and derivative reaction.

6. When the controller and control device portion of each loop are responding as designed, reconnect the sensor transmitter input line.

7. After mechanical equipment control becomes operational, perform an operational test of each control loop recording sensor, transmitter, controller input, controller output and control medium parameter.

8. Entire test shall be witnessed by an owner's representative.

9. Upon satisfactory test a copy of final test results shall be bound in the operating and maintenance manual.

3.4 FUNCTIONAL PERFORMANCE TESTING AND VERIFICATION

A. General: In addition to the tests required during and after installation of all mechanical systems, as well as any other formal commissioning requirements, the Contractor shall perform functional performance tests to verify that all systems are designed, installed, calibrated and adjusted to perform as required in the Contract.

B. Comply with all applicable specification sections including, but not be limited to, “Basic HVAC Requirements”, “Testing, Adjusting and Balancing”, “Automatic Temperature Controls” and “Commissioning”, where applicable.

C. Prior to functional performance testing, all indicating, recording and control devices shall be calibrated. A calibration verification report shall be provided with the final test report.

D. Provide functional performance testing to verify proper operation of each and every control sequence indicated throughout the contract documents.

E. Failure of Tests: Should any test, verification, or demonstration fail to meet the specification requirements, the component of the system causing the failure shall be repaired, replaced or readjusted. The failed test, verification, or demonstration shall then be repeated.

F. Test Report: Upon satisfactory verification of calibration and functional performance tests, a copy of the final test results shall be bound in the operations and maintenance manual. The final report shall also include a full compliance statement, on company letterhead, indicating that all systems are installed and functioning per the contract requirements including drawings, specifications, control sequences and accepted submittals.

G. The mechanical systems shall not be considered complete until all functional performance verification forms, calibration reports and compliance statement have been submitted and reviewed. Submit in accordance with the submittal requirements indicated elsewhere in these specifications.

3.5 DEMONSTRATION AND TRAINING

A. Demonstration: After completion of testing as hereinbefore specified, provide demonstration and training of designated operating personnel (refer to Division-1).

1. Demonstration shall be performed.

2. Demonstration shall include the operation of the entire mechanical system under the control of the Contractor and shall include the start-up, operation, and shutdown of the system in accordance with the sequence of operation.

3. The operation of each device shall be performed in accordance with the written instructions contained in the operation and maintenance manual, a copy of which shall be available ten (10) working days prior to the test. No deviation from procedures in the operating manual will be permitted.

B. Failure to Perform: Should the system fail to perform in accordance with the requirements of the operation and maintenance manual, the system shall be repaired, recalibrated, retested as necessary, and a second demonstration performed.

1. Subsequent demonstrations shall occur until the automatic control system and all associated mechanical and electrical equipment are operating in accordance with contract requirements.

2. All testing, retesting, and recalibration shall be at no additional expense. The Contractor shall reimburse the expenses of the commissioning team for each test after the first.

3.6 INSTRUCTING OPERATING PERSONNEL

A. Instructors and Superintendent: Upon completion of the work and acceptance by the representative of the Owner, provide the services of an Instructor to instruct designated operating personnel in the operation and maintenance of the automatic control system.

1. TRAINING: Meet all applicable Training requirements of Division 1, Division 15, and the following.

2. Instruct the operators how to accomplish control of the system. Include basic troubleshooting and override of equipment and controls in the event of system failure.

3. Training Allowance: Provide not less than sixteen (16) hours over not less than four (4) days of formal training to the Owner's designated operations personnel. The training hours and days are a minimum to include and final schedule shall be coordinated with the Owner. Any less hours/days shall be at the Owner's sole discretion.

4. Trainers - Persons conducting the training shall hold an advanced certification for the installed Bui8lding Automation System, be knowledgeable in the workings of the system, and shall be regularly engaged in training exercises, so as to provide effective training. Acceptability of the trainers shall be at the discretion of the Owner.

5. Training Manuals - Include the following in training manuals.

   a. Manufacturer's training brochures.

   b. Operation and maintenance manuals.

   c. Completed Field Acceptance Test Procedure.

   d. "As-installed" Drawings.

   e. Manufacturer's Operation Manuals.

   f. Software interaction sheets to be used in instructing students how to use the control system, on a command-by-command basis.

6. Training Classes - Prior to conducting training, prepare and submit for approval the proposed training literature and topics. Submit this information at least two weeks prior to the first class.

7. Provide approved training manuals to the Owner at least one week prior to the first class.

8. Provide Audio Visual Tutorials both in a CD format and on the manufacturer's website instructing on the operation of the programming software tools as provided under this specification.

3.7 BUILDING MANAGEMENT AND CONTROL SYSTEM DEVICES AND POINTS

A. Provide all building management and ATC system controllers, devices, points, etc. as required to accomplish the control sequences and equipment functions indicated throughout the contract documents, including drawings and specifications. In addition, provide all controllers, devices, points, etc. as required to control, operate, monitor and alarm all equipment and devices indicated on the contract documents (including but not limited to: chillers, cooling towers, pumps, air handling units, fans, variable frequency drives, air volume terminal units, humidifiers, valves, dampers, flow measuring devices, sensors, etc.). All points shall be available through the Energy Management Control System (EMCS). See attached points list (where applicable).

B. Building management and control points shall include status for all mechanical equipment with equipment failures alarmed at the EMCS. In addition, furnish and install all points required to provide complete, color, system graphics of all mechanical systems and components indicated throughout the contract documents. All equipment and devices indicated throughout the contract documents shall be indicated at the operator's workstation (where applicable) and all end devices shall be individually controlled unless specifically indicated otherwise.

C. Building management and control system features for equipment and devices shall include, but not be limited to, the following where applicable: runtime, trend data, optimal start, scheduling, paging, system graphics, and internet access to graphic and text-based displays.

D. Point Naming Convention: The Contractor shall utilize a consistent point naming convention throughout the building.

1. All Data Points shall be tagged in accordance with Project Haystack. (ASHRAE Standard 223P: "Designation and Classification of Semantic Tags for Building Data")

END OF SECTION 230900

SECTION 250010 - INTELLIGENT BUILDING MANAGEMENT SYSTEM (iBMS)

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, configuration and installation for an Intelligent Building Management System (also identified as iBMS, IBMS or Integrated Building Management System) as required for the complete performance of the Work, as shown on the Drawings and as specified herein.

B. The iBMS shall be provided by a qualified iBMS system supplier (also identified as Master System Integrator or MSI). The Contractor shall ultimately be responsible for the iBMS and shall supplement the system supplier's Work as necessary to provide a complete and operable system. The Contractor shall coordinate the equipment and systems provided by others that interface with the iBMS to ensure necessary interconnections and compatibility are provided for the required functionality of the iBMS.

C. The iBMS system supplier shall be the same as the system supplier for specification Section 23 09 00 Automatic Control Systems.

D. The iBMS system supplier shall not duplicate Work specified under Divisions other than Division 25 but shall be responsible for the integration, communications and functionality of those systems as specified herein. This shall include the augmentation (configuration, programming, etc.) of those systems provided by others to provide the specified integrated cross-system functionality. System suppliers under Divisions other than Division 25 are required to provide their specified system functionality, system access to the iBMS system supplier for the purpose of providing the iBMS and interface coordination for the integration specified herein.

E. Refer to the exhibits in specification Section 25 00 10 Intelligent Building Management System (iBMS) Exhibits for additional clarification of typical system supplier responsibilities by specification Division.

F. Related Sections: Possible related sections include, but shall not be limited to, the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

2. Applicable general requirements for HVAC Work specified within Division 23 Specification Sections including those for Common Work Results for HVAC specified within the subset of 23 05 ## specifications

apply to this Section. In addition, refer to the following Division 23 specifications for additional requirements:

a. Section 23 09 00 Automatic Control Systems

3. Applicable general requirements for electrical Work specified within Division 26 Specification Sections including those for Common Work Results for Electrical specified within the subset of 26 05 ## specifications apply to this Section. In addition, refer to the following Division 26 specifications for additional requirements:

a. Section 26 09 13 Electrical Submetering System

b. Section 26 09 43.23 Lighting Controls

4. Applicable general requirements for Communications Work specified within Division 27 Specification Sections including those for Common Work Results for Communications specified within the subset of 27 05 ## specifications apply to this Section. In addition, refer to the following Division 27 specifications for additional requirements:

a. Section 27 10 00 Telecommunications Structured Cabling

1.2 REFERENCES

A. General, Publications: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. International Electrotechnical Commission (IEC)

a. ISO 9001, "International Organization for Standardization"

b. IEC 62443, “Industrial Automation and Control Systems Security”

2. International Organization for Standardization (ISO)

a. ISO 9001, “Quality Management Systems - Requirements”

3. National Fire Protection Agency (NFPA)

a. NFPA 70, "National Electric Code"

b. NFPA 70E, "Standard for Electrical Safety in the Workplace"

c. NFPA 70B, "Recommended Practice for Electrical Equipment Maintenance"

d. NFPA 72, "National Fire Alarm and Signaling Code"

e. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilation Systems"

f. NFPA 90B, "Standard for the Installations of Warm Air Heating and Air Conditioning Systems"

g. NFPA 110, "Standard for Emergency and Standby Power Systems"

h. NFPA 101, "Life Safety Code"

4. Underwriters Laboratories, Inc. (UL)

a. UL / UUKL, "864 Smoke Control"

b. UL 268, "Smoke Detectors"

c. UL 916, "Energy Management"

5. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

a. ASHRAE 90.1-2016, “Energy Efficient Design of New Buildings”

b. ASHRAE 62.1-2013, “Ventilation for Acceptable Indoor Air Quality”

c. ASHRAE 189.1-2011, “Standard for the Design of High-Performance, Green Buildings”

d. ASHRAE 135-2007, “BACnet”

e. ASHRAE 55-2013, “Thermal Environmental Conditions for Human Occupancy”

1.3 DEFINITIONS

A. Unless specifically defined within the Contract Documents, the words or acronyms contained within this specification shall be as defined within, or by the references listed within this specification, the Contract Documents, or, if not listed by either, by common industry practice.

1. ACS: Access Control System

2. AFDD/CC: Automated Fault Detection and Diagnostics with Commissioning System

3. BM / BMS / BAS: Building Management System or Building Automation System

4. CMMS: Computerized Maintenance Management System

5. EPMS / EMS: Electrical Power Management System or Energy Management System

6. FIPS: Federal Information Processing Standards

7. FAS: Fire Alarm System

8. GUI: Graphic User Interface

9. HOA: Hand, Off, Auto Position Switch

10. iBMS / IBMS: Intelligent Building Management System

11. LCS: Lighting Control System

12. MSI: Master System Integrator / iBMS System Supplier

13. NTP: Network Time Protocol

14. NSC: Network Server Controller

15. PDU: Power Distribution Unit

16. SAAS: Software as a Service

17. SDCU: Standalone Digital Control Units

18. Smart Mobile Device: Smart phone or tablet compatible with iOS or Android OS capable of running apps used for specified functionality

19. VAV: Variable Air Volume or Variable Air Volume Box

20. WAGES: Water, Air, Gas, Electrical, Steam

1.4 SUBMITTALS

A. General: Submittals shall be in accordance with the requirements of Section 01 33 00 Submittals, in addition to those specified herein.

1. Submit sufficient information to determine compliance with the Contract Documents. Identify submittal data with the specific equipment tags and/or service descriptions to which they pertain. Submittal data shall be

clearly marked to identify the specific model numbers, options, and features of equipment and work proposed.

2. Deviations from the Contract Documents shall be indicated within the submittal. Each deviation shall reference the corresponding drawing or specification number, show the Contract Document requirement text and/or illustration, and shall be accompanied by a detailed written justification for the deviation.

3. Submit required product data and shop drawings specific to each product and accessory proposed. In addition, include the following information:

a. System Architecture Diagram

b. System Network Riser Diagrams

B. iBMS Software Configuration Standards and Conventions. A "Software Configuration Standards and Conventions" document shall be prepared and submitted by the system supplier after the first iBMS Software Configuration Review Meetings to document decisions made within the meeting. The document shall be submitted for review and comment before software configuration commences. All copies of this submittal shall be provided in color to ensure the accuracy of each item. No black and white copies will be accepted. The colors used in the printed submittal shall accurately depict the colors and shapes proposed for use on the final system.

C. Custom Reports required under the Summary Section shall be submitted for review and approval.

1. List of Custom Reports to be included.

2. Custom Report Templates

3. Complete Custom Reports

D. Operation & Maintenance (O&M) manuals shall be provided in accordance with the minimum requirements specified in Section 01 78 23 Operation and Maintenance Data and additional requirements specified herein.

1. Submit required Operations & Maintenance data specific to each product and accessory proposed. In addition, include the following information:

a. iBMS Sequence of Operations

b. Electronic configuration files for all configured devices and instructions to restore backup files.

E. Warranty, Software Agreement, and Service Agreement: Provide in accordance with the requirements specified in Section 23 09 00 Automatic Control Systems.

1.5 QUALITY ASSURANCE

A. Comply with all Quality Assurance requirements specified in Section 23 09 00 Automatic Control Systems.

B. iBMS Software Configuration Review Meetings

1. Prior to executing Work associated with configuring the software and functional requirements specified herein the Contractor shall schedule an iBMS Software Configuration Review Meeting between the iBMS system supplier, the system suppliers of the systems being integrated at the Owner's facilities. The purpose of this meeting shall be to coordinate and ensure the following between systems:

a. GUI conventions

b. Report formats

c. System coordination

2. The iBMS system supplier shall provide a project specific example of a specified application functional requirement in the production environment that shows all sequences and proposed GUI conventions for review prior to commencing work on the remaining applications of the system.

3. The Contractor shall schedule a second meeting at the Owner's facilities to review each specified application functional requirement(s) in the production environment and correct prior to onsite installation.

C. All work performed and all materials used shall be in accordance with the National Electrical Code and with applicable local regulations and ordinances. Equipment assemblies, materials, and equipment shall be listed and labeled by Underwriter's Laboratories or by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE AND HANDLING

A. Prior to delivery to the Project site, ensure that suitable storage space is available to store materials in a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres. Materials shall be protected during delivery and storage and shall not exceed the manufacturer stated storage requirements. As a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. In addition, protect electronics from all forms of electrical and magnetic energy that could reasonably cause damage.

B. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name,

material or product brand name, and equipment tag number or service name as identified within the Contract Documents.

C. Inspect and report any concealed damage or violation of delivery storage, and handling requirements to the Engineer.

1.7 WARRANTY

A. Provide Warranty in accordance with the requirements specified in Section 23 09 00 Automatic Control Systems.

1.8 SPECIAL TOOLS AND SPARE PARTS

A. Provide Spare Parts / Attic Stock in accordance with the requirements specified in Section 23 09 00 Automatic Control Systems.

PART 2 - PRODUCTS

2.1 INTEGRATED SYSTEM ARCHITECTURE.

A. Prior to bidding, the Contractor shall ensure that the Project architecture of the iBMS specified herein and that of the systems integrated specified under other Divisions are a validated system architecture of the manufacture(s) of those systems. The Contractor shall list the iBMS system supplier and the manufacture(s) of the systems to be integrated on the bid form.

B. Basis-of-Design Architecture: Subject to compliance with requirements, provide architectures for integrated intelligent building management systems by one of the following pre-qualified manufacturers:

1. EcoStruxure Building Management platform as developed by Schneider Electric.

2. Niagara 4 Framework platform as developed by the Tridium Corporation.

C. Intelligent Building Management System (iBMS) specified herein shall be provided by a single system supplier. Systems, products and manufacturers specified are to establish a standard of quality for design, function, materials, and appearance. Products shall be modified as necessary for compliance with requirements. Provide the specified product and manufacturer without exception, unless allowed as a substitute per the general provisions of the Contract.

D. The architecture of the iBMS provided by the system supplier shall be based on using the building management system of specification section 23 09 00 Automatic Control Systems (Electric-Electronic) as the foundation for integrating systems and as the primary GUI interface to the user.

2.2 GENERAL REQUIREMENTS

A. General Communication Protocols and Sub-System Interface Performance Requirements:

1. Integration between systems shall be run on a computing environment that will auto start the integration when recovering from a power outage. Upon restart of any integration software host device, a manual user logon and authentication shall not be required to occur at the system nor network domain level for the interface to function in normal mode.

2. Watchdog functionality shall be built that tests the system-to-system communication and business functionality at least every five minutes and will alarm in the iBMS if communication fails. Watchdog alarms shall be emailed to a designated list of recipients within 60 seconds of not receiving the test transactions from the iBMS.

3. Any core system functionality within the iBMS shall have the following abilities:

a. Browse the list of objects and attributes available via web services from other core systems.

b. Consume information via web services from other core systems.

c. View and acknowledge active alarms via web services from other core systems.

d. Consume historical Log information via web services from other core systems.

4. Data exchange shall be based on the Change of Value (COV) or upon request to limit network traffic and provide data responsiveness.

B. Time Series Data Logging – Buildings and Business Analytics Requirements:

1. iBMS Data Storage Server (DSS) and reporting capability shall be provided with the ability to store and query large volumes of data. This shall include trends over long periods of time to compare values such as indoor and outdoor environment conditions, equipment status and energy utilization.

2. It shall be possible for the iBMS DSS to store large quantities of timed sequenced records limited only by the capacity of the storage media.

3. Data from the DSS shall be available for copy within the building premises, corporate data storage or compatible cloud storage validated and approved for use by the iBMS system integrator.

4. The quantity of data points which can be stored on the DSS shall only be equal to the number of objects that are defined on the BMS NSC and STCU building management system as specified in Section 23 09 00 Automatic Control Systems (Electric-Electronic).

5. The DSS shall be capable of storing data from subsystems integrated to the iBMS.

6. It shall be possible to capture any point data value at 5 minute intervals and store the data for a minimum of 5 years.

7. Postgres SQL compatible analytical and reporting tools including but not limited to; Azure Analytics, "R", Jaspersoft, Qlik and Tableau shall be able to access and analyze data from the DSS.

C. Cyber Security Requirements:

1. Intelligent Building Management System software cyber security requirements:

a. The iBMS shall be developed using secure development life cycle best practices for software development.

b. The iBMS shall be subjected to regular and verifiable best practice cyber security testing by the system supplier. Results of this testing shall be made available upon request prior to deployment of the system.

c. The iBMS system supplier shall provide cyber security service incident escalation through help desk on a 7/24/365 basis.

d. All iBMS server level devices shall require access via HTTPS.

e. All iBMS AS shall support SNMP V3 monitoring of network performance and stack statistics for the purpose of managing denial of service attacks.

f. The iBMS shall support the feature to auto logoff any logon that has had no activity for a predefined period of time.

g. The iBMS shall support the feature to alarm on a predetermined period of time until the default password for each device is changed from the default factory setting.

h. The iBMS shall support encrypted password authentication for all web services whether serving or consuming.

i. The iBMS shall support single sign on allowing user authentication information to be shared from one trusted system

to another. All cyber security standards and practices shall apply to secure the single sign on.

j. The iBMS shall support Active Directory.

k. The iBMS shall support password rules required by good security practices to include: password complexity, password history, minimum password length, password age, forced password change, invalid login alert, auto lock out after three invalid attempts.

2. Secure network environment requirements:

a. The iBMS network level servers shall support encryption standard throughout the network without.

2.3 INTEGRATED BUILDING NETWORK

A. The iBMS system supplier shall provide an integrated building network for the iBMS to include connections to workstations, webstations and servers of the iBMS, as well as, connections to subnetworks of systems being integrated. Each system to be integrated shall be responsible for its own network communications to provide its specified functionality including an acceptable network interface to the iBMS integrated building network.

B. The integrated building network shall enable the Intelligent Building Management System (iBMS) to connect to the following subsystems (as applicable):

1. Building Automation System

2. Lighting Control Systems (Panels and Servers)

3. Generators and associated panels and electrical gear

4. Fuel Tank Monitoring Systems

5. Fire Alarm Network Interface

6. Firewall Interface

7. IT Network SNMP Monitoring Host

8. Any additional subsystems as required to complete the requirements on the drawings and other specification sections.

C. Include racks or network cabinets as required by the drawings or as required by project plans. Racks shall have PDU's and local UPS Backup. UPS backup shall be a minimum ten (10) minutes runtime.

D. Network switches shall be layer 3 managed type switches, Cisco Model IE 2000/4000/4010 or equivalent either ethernet or fiber / ethernet as required.

E. Cyber Security:

1. The iBMS shall meet all applicable requirements of IEC 62443.

2. The Integrated Building Network shall be protected from the outside world via configurable firewalls at each point of internet or corporate network connection.

3. Different subsystems of the Intelligent Building Management System shall be configured on separate VLANs provided by the iBMS Owner.

4. VLANs shall separate all tenant's systems from shell and core systems. Ports on the layer 3 network switches shall be configured to allow the transfer of necessary data between tenant and landlord shell and core systems.

5. The ports on the firewall shall be configured to only allow the required information to pass through in the required direction (out of building / into building).

6. Integrated Control System devices / controllers shall be cyber security tested to ensure the risk of a security breach is minimized.

7. VPN software shall be used for any remote access into the Intelligent Building Management System.

F. Manageability:

1. Network switches shall be layer 3 managed type switches either ethernet or fiber/ethernet as required.

2. The Integrated Building Network shall be manageable from a network management software capable of displaying network topology map, providing management, switch configuration and troubleshooting capability of all VLANs.

3. It shall be possible to configure network switches in an off-line mode inclusive of Switch Operating System, Port Assignments, VLAN Management, RSTP and DHCP Server settings. The off-line setting templates shall be downloadable to the network of switches at time of commissioning.

4. It shall be possible to back up the settings of the switches and to restore the settings to a replacement switch in the event of hardware failure.

5. It shall be possible to mirror traffic from a VLAN onto a switch port for network traffic analysis and troubleshooting.

G. Resiliency: The Integrated Building Network shall be capable of supporting RSTP (IEEE 802.1w) ring topology for network resiliency.

H. Structured Cabling

1. Refer to Division 27 Communications for structured cabling requirements.

2. All wire shall be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	22 Gauge Std.	300 Volt
Communications	per mfr.	per mfr.

3. Communication and signal circuit used for integration shall not be installed in the same conduit as lighting or power circuits.

4. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

5. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum ¾ inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fittings where exterior conduits enter the building or between areas of high temperature/moisture differential, and also for any room that requires ventilation pressure differential.

6. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

7. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location junction boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

8. When the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

9. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.

10. Only glass fiber is acceptable. Plastic is unacceptable.

11. Fiber optic cable shall only be installed and terminated by an experienced contractor. The iBMS system supplier shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

2.4 SYSTEM TO SYSTEM INTEGRATED LIGHTING CONTROL

A. The iBMS system supplier shall provide the necessary Work for Integrated Lighting Control and shall include the following as required for specified functionality.

1. Not used.

2. Not used.

3. Interface to electrical equipment to provide lighting control.

B. Not used.

C. The iBMS shall integrate with the networked lighting control system to override and schedule scenes, light levels, and room occupancy mode, occupied and unoccupied levels. Functionalities shall remain independent in the event of communication loss between the two systems. The iBMS shall provide the mater schedule between systems.

D. Scheduling: The iBMS shall integrate occupancy schedules from a common user scheduling system as the master schedule. This schedule occupancy information shall be used to activate automatic control sequences for comfort, wellness and energy as defined within Division 23 HVAC mechanical systems and Div. 26 Lighting Controls.

1. The system integrator shall coordinate mapping of the HVAC and Lighting Control sequences, scenes and zones to ensure that the master scheduling can properly control both HVAC and Lighting seamlessly.

E. Communication Protocols and Interfaces Performance:

1. This integration shall be done via BACnet IP, Web Service API or the inherent protocol of the Intelligent Building Management System.

2. If using BACnet IP, only integrations that support Device Change of Value (“COV”) Subscriptions, Description, Location, and Profile Name shall be accepted.

F. Lighting Control Graphical User Interface:

1. A graphical user interface showing floorplans with lighting control zones shall be included in the iBMS.

2.5 INTEGRATED ENERGY AND POWER MANAGEMENT

A. Not applicable.

PART 3 - EXECUTION

3.1 GENERAL

A. Examine equipment exterior and interior prior to installation. Report any damage and do not install any equipment that is structurally, moisture, or mildew damaged.

B. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

C. Pre-Installation Conference: Prior to commencing the installation, an onsite pre-installation conference shall review the material selections, installation procedures, and coordination with other trades. Attendees shall include, but shall not be limited to, the Contractor, the Installer, manufacturer's representatives, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Engineer.

D. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

E. Install equipment in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.

F. Provide final protection and maintain conditions in a manner acceptable to the manufacturer that shall help ensure that the equipment is without damage at time of Substantial Completion.

3.2 FACTORY ACCEPTANCE TESTING

A. Factory testing shall be performed on all integrations prior to installation on site.

B. Testing shall include a written description and block diagram describing the integration.

C. Testing shall include the following:

1. Functional description of the integration including intended usage.

2. Data definition of all data elements to be transferred.

3. Data throughput performance of the data to be transferred.

4. Failure and recovery mode documentation and testing.

5. Data access and permissions for machine to machine connection set up and maintenance.

6. Review of all configuration steps needed to commission the integrations.

7. Review of all administrative tools needed to commission the integrations.

8. Review of all administration tools needed to monitor the operation performance of the integrations.

9. Cyber security analysis and testing.

10. Physical cabling and connectors required between systems prior to installation.

11. Review and test of logical network configurations including switches, routers, VLANs and network address assignment.

3.3 FIELD QUALITY CONTROL

A. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory-trained manufacturer's field service representative. This manufacturer's field service technician shall provide all material, equipment, labor and technical supervision to perform inspection, testing and adjustments to ensure equipment is installed, adjusted, and tested in accordance with the manufacturer's recommendations and is ready for operation. The manufacturer's field service technician shall replace damaged or malfunctioning equipment and report to the Engineer any discrepancies or issues with the installation.

1. The manufacturer's representative shall monitor stability of system integrations and adjust watchdog alarms sequences to limit nuisance alarms.

B. The manufacturer's representative shall, upon satisfactory completion of inspection and testing, attach a label to all serviced devices indicating the date serviced and testing company responsible.

3.4 FIELD TESTING AND COMMISSIONING

A. Operational Readiness Testing

1. The Contractor shall inspect and test furnished equipment and associated systems for conformance to the contract documents, including equipment manufacture's recommendations, and readiness for operation. The test shall include the following as a minimum:

a. Visually inspect for physical damage and proper installation.

b. Perform tests in accordance with manufacturer's instructions.

c. Perform tests to ensure compliance with Contract Documents.

d. Perform tests that equipment is ready for operation.

e. Touch-up paint all chips and scratches with manufacturer-supplied paint and transfer remaining paint to Owner

2. Contractor shall submit an operational readiness test report documenting all test results, including all assumptions, conditions, allowances and corrections made during the test. The report shall provide a listing of all modifications and adjustments made onsite to include any settings / parameters not identified as factory defaults within the equipment's O&M documentation. The test report shall include a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

B. Functional Demonstration Testing

1. Prior to scheduling functional demonstration testing the Contractor shall submit a signed statement from the Contractor, installer(s) and the factory-trained manufacturer's representative(s) certifying that the furnished equipment and associated system have been installed, configured, and tested in accordance with the manufacturer's recommendations, completely conforms to the requirements of the Contract Documents and is ready for operation.

2. The Contractor shall demonstrate the functionality and performance of the equipment and associated systems in the presence of Owner and Engineer, observing and documenting complete compliance with the Contract Documents.

3. The Contractor shall demonstrate all critical applications and shall demonstrate all other applications to validate proper configuration and object naming. If during that trial a failure rate of greater than 5% is found the iBMS system supplier is responsible for certifying all points related to the application use case for proper functionality and performance.

4. The Contractor shall submit a written report documenting successful completion of functional demonstrating testing including all assumptions, conditions, allowances and corrections made during the test.

3.5 TRAINING

A. O&M Training: Onsite training specific to the equipment furnished shall be provided to the Owner's staff by a factory trained manufacturer's representative. Training duration shall be sufficiently adequate to cover the operation and maintenance of the equipment and shall consist of not less than 1 session(s) with 24 hours of onsite classroom and hands-on instruction for a minimum of 4 attendees per session.

1. The instructor shall provide sufficient time and detail in each session to cover the following as a minimum:

a. Theory of operation

b. Major components of equipment

c. Operation of equipment

d. Configurations of equipment

e. Maintenance, troubleshooting and repair

f. Replacement of component level parts

2. The submitted O&M manuals shall be used for training

END OF SECTION 250010

SECTION 25 00 10 E

INTELLIGENT BUILDING MANAGEMENT SYSTEM (iBMS) EXHIBITS

PART 1 - EXHIBITS

1.1 iBMS SPECIFICATION DIVISION TABLE

A. The following table helps clarify the typical scope provided under the various Divisions. Please note that the Contractor is ultimately responsible for all Work required for the specified functionality.

		GC / Owner	Div 23 (Mechanical)	Div 23 (BMS)	Div 26 (Electrical)	Div 27 (Teledata)	Div 28 (Security)	Div 25 (Integrator)
BMS	Furnish BMS Server and Workstations			X				
	Furnish BMS Controllers			X				
	Install BMS Controllers			X				
	120V Power for BMS Controllers				X			
	24V Power for BMS Controllers			X				
	Furnish Thermostats / Room Controllers			X				
	Install Thermostats / Room Controllers			X				
	Furnish Control Valves			X				
	Install Control Valves		X					
	120V Power Control Valves				X			
	24V Power for Control Valves			X				
	Furnish Motorized Damper Actuators			X				
	Install Motorized Damper Actuators			X				
	120V Power for Motorized Dampers				X			

	24V Power for Motorized Dampers			X				
	Furnish and Install Stubups				X			
	Core Drills				X			
	Furnish and Install Sleeves				X			
	Provide Interface to Integrated Automation System							X
	Provide Interface to Fire Alarm System							X

Telecom	Furnish and Install Single Mode Fiber					X		
	Furnish and Install Multi Mode Fiber					X		
	Conduit for Telecom distribu-tion pathways				X			
	Grounding for IT Closets				X			
	Build Out IT Closets (Racks, PDU's, UPS's)					X		
	120V Power for IT Closets				X			
	Furnish WAP Wireless Access Points					X		
	Install WAP Wireless Access Points					X		
	Furnish VOIP Telephones					X		
	Install VOIP Telephones					X		
	Furnish Network Switches					X		
	Install and Program Network Switches					X		
	Furnish and Set Up Firewall					X		
	Provide Network Connection	X						
	Furnish Facilities Network RJ-45 drops					X		
	Install Facilities Network RJ-45 drops					X		
	Coordinate Network drops for Low Voltage Systems							X

Lighting Control	Furnish Lighting Control System				X			
	Install Lighting Control System				X			
	120V Power for Lighting Control System				X			
	Furnish Interface to Lighting Control System							X
Power Monitoring	Furnish Power Monitoring Server & Software				X			
	Furnish Electrical Meters				X			
	Install Electrical Meters (Mount and CT's)				X			
	Program and Commission Power Meters				X			
	Wire Communications from Meter to Network Switch				X			
	Interface to Power Metering System							X

END OF SECTION 25 00 10 E

SECTION 271000 - TELECOMMUNICATIONS STRUCTURED CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 REFERENCES

A. Building Industry Consulting Services International (BiCSi),"Telecommunications Distributions Methods Manual," Thirteenth Edition.

B. American National Standards Institute/Telecommunications Industry Association (ANSI/TIA)-568.2-D, "Commercial Building Telecommunications Wiring Standard"

C. ANSI/TIA-569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces"

D. ANSI/TIA-606C, “Administration Standard for the Telecommunications Infrastructure of Commercial Buildings”

E. ANSI/TIA-607-C, “Commercial Building Grounding/Bonding Requirements”

F. National Electrical Code (NEC), 2017 - National Fire Protection Agency (NFPA) 70

G. Institute of Electrical and Electronic Engineers (IEEE) 802.3 Carrier Sense Multiple Access with Collision Detection (Ethernet 100BASE-T)

H. Federal Communications Commission (FCC), Title 47, Code of Federal Regulations, Part 68.

I. National Institution for Certification in Engineering Technologies (NICET)

J. International Communications Industry Association (ICIA).

1.3 SUMMARY

A. Section Includes:

1. UTP cabling.

2. Coaxial cable (radio frequency video).

3. Cable connecting hardware, patch panels, and cross-connects.

4. Telecommunications outlet/connectors.

5. Cable management system.

6. Cabling identification products.

7. Telecommunications Pathways.

8. Telecommunications mounting elements.

B. Bidding Requirements:

1. Bidder shall submit complete detailed proposals with line item cost representation for components and associated installation labor. Lump sum bids will not be accepted.

2. Bidders shall include as part of the bid response the following items:

a. Installation schedule with proposed manpower assignments.

b. Resumes for project manager and lead technician for this project.

c. BICSI RCDD certificate and registration number.

3. Bidders shall review associated electrical and telecommunications infrastructure drawings to verify that necessary conduit and floor boxes will be provided by others. Bidders shall understand and coordinate shared infrastructure locations for telecommunications outlets. The Owner will provide no additional infrastructure to support the telecommunications cabling systems Inside Plant (ISP) and Outside Plant (OSP). Any discrepancies with the identified infrastructure to support these systems should be questioned in the form of a request for information (RFI) during the bidding process. Be responsible for any additional infrastructure requirements after receipt of contract for this project. No wiremold or surface mounted raceways shall be approved on this project except where specifically identified in the contract drawings.

4. Unspecified Equipment and Material: Any item of equipment or material not specifically addressed on the drawings or in this document and required to provide a complete and functional Structured Cabling System shall be provided in a level of quality consistent with other specified items.

1.4 DEFINITIONS

A. AFC: Above Finished Ceiling

B. BICSI: Building Industry Consulting Service International

C. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways

D. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection

E. EF: Entrance Facility

F. EMI: Electromagnetic interference

G. HC: Horizontal Cross Connect

H. IDC: Insulation displacement connector

I. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs)

J. LAN: Local Area Network

K. MC: Main Cross-connect

L. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors

M. NRTL: Nationally Recognized Testing Laboratory

N. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates

O. RCDD: Registered Communications Distribution Designer

P. TR: Telecommunications Room

1.5 SYSTEM DESCRIPTION

A. Provide a complete and functioning Structured Cabling System inclusive of all hardware, software, and training to meet or exceed the performance features outlined in this document.

B. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. ANSI/ANSI/TIA-568.2-D requires that a minimum of two telecommunications outlet/connectors be installed for each work area.

2. A work area is approximately 100 sq. ft., and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

3. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.

4. Bridged taps and splices shall not be installed in the horizontal cabling.

5. Splitters shall not be installed as part of the optical fiber cabling.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

D. Communications equipment room shall provide the space to house the equipment for the backbone and horizontal cabling.

1.6 PERFORMANCE REQUIREMENTS

A. General Performance: The cabling system shall comply with transmission standards in ANSI/TIAANSI/TIA-568.2-D when tested according to the test procedures of this standard.

1.7 SUBMITTALS

A. Comply with requirements of Section 01 33 00 - Submittal Procedures.

B. Submittal Data

1. Submittal data is to be submitted as a complete, single digital file. All documents shall be clearly legible. Each submittal shall contain the below in the following order:

a. Cover Sheet.

1) Include name of supplying contractor and project name.

2) Include submittal and revision number.

b. Detailed Bill of Materials.

1) Include a listing of component quantities, equipment manufacturers, model numbers, and descriptions of each component being supplied and the specification paragraphs or drawing sheets that correspond to each product.

2) The bill of materials shall include page numbers for each product data sheet and be index referenced within the PDF file so that each product name is clickable, linked to the first page of the corresponding product data.

3) Failure to provide this information will result in the rejection of submittals.

c. Product Data.

1) Include a catalog sheet per product of equipment listed in the Detailed Bill of Materials, in the exact order as the Detailed Bill of Materials. Each catalog sheet shall describe mechanical, electrical and functional equipment specifications. The catalog sheet must also include an image of the product.

2) Photocopy duplications of the manufacturer's original equipment catalog sheets will be allowed as long as they provide adequate clarity of both the printed word and graphics/pictures.

3) If more than one product is shown on the catalog sheet the intended product must be denoted by either an arrow or highlight.

d. Authorized Distributor Certificate.

1) Recently dated (within one year from submittal date) support letter from manufacturer stating that the supplying contractor is an Authorized Distributor of the product being supplied.

e. Prequalification Warrantee.

1) Recently dated (within one year from submittal date) support letter from manufacturer stating that the supplying contractor is Authorized to obtain for the owner the Special Warranty for Cabling System and the Special Warranty for System Assurance.

f. Prequalification Certificate.

1) Copy of the installing technician(s) certificate of completion from the manufacturer's training school for the equipment being provided.

2. Partial submittals, or submittals comprised of multiple PDF files, will not be accepted.

C. Shop Drawings

1. Prior to fabrication submit contractor-generated drawings for approval for all supplied systems. Shop Drawings are to be submitted on project standard full size and bound. Each shop drawing set is to include the below in the following order:

a. Title Sheet.

1) Include a list of all drawings in the set and a symbols legend defining each symbol used in the package.

b. Video/CATV System Engineering

1) Depict device location by room number and device type. Delineate cable types and cable pathway for both riser and horizontal distribution. Calculate db loss and outline levels for each splitter, tap, amplifier, and outlet.

c. Typical Outlet Details.

1) Detail each typical outlet type to be installed. Include manufacturer specific plates, jacks, and an example of labeling. Note on the drawing the typical application of each outlet type, for example; standard office, computer lab, ceiling mounted wireless access location, etc.

d. d. Floor Plans.

1) Show planned location for all elements and cable routing.

2) Drawings should be at project standard scale clearly legible. Include outlet port numbers for each outlet.

2. Resubmission of contract drawings does not constitute a complete shop drawings submittal and is unacceptable. Such submittals will be rejected.

D. Product data and shop drawings must be submitted together in order to be reviewed.

E. Samples shall be submitted for each typical outlet type to be installed, complete with colored jacks, finished faceplates, and sample labeling.

F. Field quality-control reports.

1. Submit copy of project status reporting form.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings by an RCDD.

2. Installation Supervision: Installation shall be under the direct supervision of Level 2 installer and manufactures certified installer, who shall be present at all times when work of this section is performed at project site. At a minimum, one half of remainder of the crew shall be registered technicians by the specified manufacturer as part of their Certified Installer Program.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.

2. Smoke-Developed Index: 50 or less.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Installing company shall be certified by manufactures in aspects of design, installation and testing of optical and Category rated metallic premise distribution systems, be a manufactures Value Added Reseller (VAR) in good standing, have a minimum of five (5) years' experience on similar Structured Cabling Systems (SCS), and have a Registered Communications Distribution Designer (RCDD) on staff.

E. Telecommunications Pathways and Spaces: Comply with ANSI/TIAANSI/TIA-569-D.

F. Administration Standard for the Telecommunications Infrastructure of Commercial Buildings, 2017 ANSI/ANSI/TIA–606-C.

G. Grounding: Comply with ANSI-J-STD-607-C.

H. NFPA 70 – National Electric Code, latest edition.

I. BICSI – Telecommunications Distribution Methods Manual, 13th Edition, 2015

J. NEMA – VE-1 – Metal Cable Tray Systems, 2017

K. NEMA – VE-2 – Metal Cable Tray Installation Guidelines, 2013

1.9 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use an optical loss test set.

2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

3. Test each pair of UTP cable for open and short circuits.

B. Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

B. Environmental Limitations: Do not deliver or install equipment frames and ladder racking until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.11 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.

2. Record agreements reached in meetings and distribute them to other participants.

3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other

communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

C. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

D. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.12 EXTRA MATERIALS

A. Spare Attic Stock shall be EXCLUDED from bid pricing. Contractor shall review required spare parts & attic stock with Owner prior to project turnover.

1.13 WARRANTY

A. Warranty / Guarantee: The work provided under this contract shall be free from defects in workmanship and material under normal use and service. The Contractor shall furnish a guarantee covering all labor and materials furnished by him for a period of two (2) years from the date of final acceptance of his work, and he shall agree to repair and make good at his own expense any and all defects which may appear in his work during that time if such defects arise from defective workmanship and/or imperfect or inferior material.

1. The warranty shall extend to material that is supplied and installed by the Contractor. Material supplied but not installed by the Contractor shall be covered per the above to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PATHWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, and are limited to, the following:

1. Basis of design: ERICO

2. Approved equals by:

   a. Cooper/BN-line

   b. Hilti Inc.

B. General Requirements: Comply with ANSI/TIAANSI/TIA-569-D.

C. Cable Support: NRTL labeled. Cable support brackets in Telecommunications Rooms shall be designed to prevent degradation of cable performance and pinch points that could damage cable.

D. Provide bend limiters, if not built into the cable support, to maintain cable type bend radius whenever cable exists pathways or makes transition between two pathways.

E. Non-continuous cable supports shall be used in any area above the finished ceiling where cable tray is not available.

F. Non-continuous cable supports

1. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

2. Non-continuous cable supports shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables; cULus Listed.

3. Non-continuous cable supports shall have flared edges to prevent damage while installing cables.

4. Non-continuous cable supports sized 1 5/16” and larger shall have a cable retainer strap to provide containment of cables within the hanger. The cable retainer strap shall be removable and reusable and be suitable for use in air handling spaces.

5. Non-continuous cable supports shall have an electro-galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.

6. Non-continuous cable supports shall be ERICO CableCatTM J-hook series CAT12, CAT21, CAT32, CAT64, CAT21SS, CAT32SS, CAT64SS; CAT-CMTM Double J-Hook CAT100CM; CAT-CMTM U-hook series CAT200CMLN, CAT300CMLN; and CAT- CMTM retainer CATRT200CM, CATRT300CM or approved equal.

G. Non-continuous cable support assemblies from drop wire/ceiling

1. Fastener to wire/rod with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.

2. Acceptable products: ERICO CADDY CAT124Z34, CAT126Z34, CAT214Z34, CAT216Z34, CAT324Z34 or CAT326Z34; or approved equal.

H. Non-continuous cable support assemblies from beam, flange

1. Fastener to beam or flange with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments; cULus Listed.

2. Acceptable products: ERICO CableCatTM J-hook series CAT12, CAT21, CAT32, CAT64 with CADDY beam clamps and CADDY flange clips; or approved equal.

I. Non-continuous cable support assemblies from C & Z Purlin

1. Fastener to C or Z purlin with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus listed.

2. Acceptable products: ERICO CableCatTM J-hook series CAT12, CAT21, CAT32, CAT64 with CADDY Purlin hangers; or approved equal.

J. Non-continuous cable support assemblies from wall, concrete, or joist

1. Fastener to wall, concrete, or joist with one non-continuous cable support, factory or jobsite assembled; rated for indoor use in non-corrosive environments, cULus listed.

2. Acceptable products: ERICO CableCatTM J-hook series CAT12, CAT21, CAT32, CAT64, with CADDY angle bracket; or approved equal.

K. Non-continuous cable support assemblies from threaded rod

1. Fastener to threaded rod with one non-continuous cable support, factory or jobsite assembled, rated for indoor use in non-corrosive environments, cULus Listed.

2. The multi-tiered support bracket shall have a static load limit of 300 lbs.

3. U-hooks and Double J-hook shall attach directly to threaded rod using standard nuts.

4. Acceptable products: ERICO CableCatTM J-hook, CAT12, CAT21, CAT32, CAT64 with CADDY CATHBA series; CAT-CMTM Double J-

hook CAT100CM, CAT-CMTM Direct mount U-hook CAT200CMLN, CAT300CMLN; or AFAB series; or approved equal.

L. Raised floor non-continuous cable support assemblies

1. Fastener to raised (access) floor pedestal with one non-continuous cable support, factory or jobsite assembled, rated for indoor use in non-corrosive environments; cULus Listed.

2. Acceptable products: ERICO CADDY CAT12CD1B, CAT21CD1B or CAT32CD1B; CAT64CD1B; or approved equal.

2.3 CONDUIT AND BOXES

A. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceways and Boxes." Flexible metal conduit shall not be used.

1. Outlet boxes shall be no smaller than 5 inches wide, 5 inches high, and 2.875 inches deep.

2.4 UTP CABLE

A. Manufacturers: Subject to compliance with the specified requirements, provide products by one of the following available manufacturers. Manufacturers offering products that may be incorporated into the work include, but are limited to, the following:

1. Berk-Tek; a Nexans company.

2. CommScope, Inc.

3. Mohawk; a division of Belden CDT.

4. Superior Essex Inc.

5. SYSTIMAX Solutions; a CommScope, Inc. brand.

6. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

7. Belden, Inc.

B. Description: 100-ohm, 4-pair UTP, covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.

2. Comply with ANSI/TIAANSI/TIA-568.2-D for performance specifications.

3. Comply with ANSI/TIAANSI-TIA-568.2-D, Category 6

4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

   a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.

5. Wire Color Coding:

   a. Orange - BAS

2.5 UTP CABLE HARDWARE

A. Manufacturers Subject to compliance with the specified requirements, provide products by one of the following available manufacturers. Manufacturers offering products that may be incorporated into the work include, but are limited to, the following:

1. Berk-Tek; a Nexans company.

2. CommScope, Inc.

3. Mohawk; a division of Belden CDT.

4. Superior Essex Inc.

5. SYSTIMAX Solutions; a CommScope, Inc. brand.

6. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

7. Belden, Inc.

B. General Requirements for Cable Connecting Hardware: Comply with ANSI/TIAANSI/TIA-568- D, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables. All patch panels shall be 48 port.

1. Number of Jacks per Field: Provide one for each four-pair UTP cable indicated conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

D. Jacks and Jack Assemblies: Modular, color-coded, eight-position eight conductor modular receptacle units with integral IDC-type terminals.

1. Comply with ANSI/TIAANSI/TIA-568.2-D, Category 6

E. Patch Cords: Factory-made, four-pair cables in 3'-20' in length; terminated with eight-position modular plug at each end. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure specified category performance. Patch cords shall have latch guards to protect against snagging.

1. TR location: Provide one (1) patch cord to match cable and Jack Assembly category rating per port on the patch panel.

2. Floor outlet locations: Provide one (1) ten foot modular patch cord to match cable and Jack Assembly category rating per eight-position eight conductor modular receptacle.

2.6 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with ANSI/TIAANSI/TIA-568.2-D.

B. Workstation Outlets: Provide connector assemblies mounted in single or multigang faceplates as shown on contract drawings.

1. Metal Faceplate: Stainless steel complying with requirements in Division 26 Section "Wiring Devices."

2. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.

3. Legend: Factory labeled by silk-screening or engraving.

4. Legend: Machine printed, in the field, using adhesive-tape label.

5. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.7 OPTICAL FIBER CABLE MANUFACTURERS

A. Subject to compliance with the specified requirements, provide products by one of the following available manufacturers. Manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:

1. Superior Essex Inc.

2. CommScope, Inc.

3. Corning Cable Systems

4. General Cable Technologies Corporation

5. Belden, Inc.

6. Mohawk; a division of Belden CDT

7. Optical Cable Corporation

8. Uniprise; a CommScope, Inc. brand

9. SYSTIMAX Solutions; a CommScope Inc. brand

10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

11. Hitachi Cable America Inc.

B. Indoor OS2 Singlemode

1. Description: 12-strand fiber, armored nonconductive, tight buffer optical fiber cable

2. Comply with ICEA S-83-596 for mechanical properties.

3. Comply with ANSI/TIA-568.3-D for performance specifications.

4. Comply with ANSI/TIA-492-CAAA for detailed specifications.

5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262

6. Maximum Attenuation: 0.3 dB/km at 1550 nm

7. Jacket:

a. Jacket Color: Yellow

b. Cable cordage jacket, fiber, unit, and group color shall comply with ANSI/TIA-598- B.

c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

2.8 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with the specified requirements, provide products by one of the following available manufacturers. Manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:

1. Hubbell Premise Wiring.

2. Leviton Voice & Data Division.

3. Nordex/CDT; a subsidiary of Cable Design Technologies.

4. Panduit Corp.

5. Siemon Co. (The)

6. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

7. Belden, Inc.

8. Ortronics Corp.

9. Corning Cable Systems

10. Optical Cable Corporation (OCC)

11. Hellermann Tyton

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, simplex and duplex cable connectors

1. Number of Connectors per Field: Provide one for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit the specified expansion criteria.

2. Fiber optic enclosures shall be rack-mountable with accommodations for splice trays.

3. Install fusion splice trays as needed for transition points and factory terminated pigtails.

4. LC duplex 12-fiber coupler panels shall be used for singlemode fiber.

5. Size fiber enclosure for 25% percent spare capacity.

C. Patch Cords: Provide factory-made, dual-fiber cables in one (1) meter lengths. Supply LC duplex for one-half of the total termination points.

D. Patch Cords: Provide factory-made, dual-fiber cables in three (3) meter lengths. Supply LC duplex for one-half of the total termination points.

E. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of ANSI/TIA-604-2, ANSI/TIA-604-3-A, and ANSI/TIA-604-12. Comply with ANSI/TIA-568.3-D.

2. Singlemode connector type: LC

3. Connectors for multimode and singlemode shall be field installed via fusion splicing.

2.9 EQUIPMENT FRAMES

A. Wall mounted horizontal distribution cabinet – Tripplite #SRW10US

2.10 CABLE MANAGEMENT

A. Horizontal Cable Management for Racks, Frames or Cabinets

B. Place horizontal cable managers above and below each patch panel in each rack/cabinet. The horizontal cable manager will guide patch/equipment cords between the vertical cable manager and individual network port connections.

C. Provide 2 RMU of horizontal cable management above and below every patch panel. Cables must be able to access the cable manager so that no ports are blocked by the cables.

D. The manufacturer will state estimated cable fills for the cable manager in the product data sheet.

E. The horizontal cable manager will match the rack-mount width of the racks/cabinets.

F. The horizontal cable manager will attach to the front or rear of the rack/frame/cabinet with screws and will be sized to fit within standard EIA-310-D (1-3/4" high RMU) rack-mount spacing. The manufacturer of the horizontal cable manager will sell compatible racks/cabinets.

G. Design Make: Tripplite SRCABLERING2U, Black or approved equal.

2.11 POWER STRIPS

A. One per rack

B. NEMA L5-20P with 10ft. cord

C. Tripp-Lite PDUMH15-ISO or approved equal.

2.12 NETWORK SWITCH

A. 24 Port Switch – HPE Aruba 2930F 24G 4SFP (JL259A)

B. Single Mode SFP Module

2.13 FIRE STOP CABLE PASS-THRU SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are limited to, the following:

1. Basis of design: Specified Technologies Inc.

2. Approved equal by:

a. 3M Corporation

b. Hilti Corporation

c. Wiremold- Legrand Corporation

B. Fire Rated Cable Pathways: STI EZ-PATH Brand device modules comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:

1. Specified Technologies Inc. (STI) EZ-PATH Series 44 Fire Rated Pathway

2. Specified Technologies Inc. (STI) EZ-PATH Series 33 Fire Rated Pathway

C. EZ-path series 44 wall sleeves shall be provided for all telecom room penetrations to cable distribution system.

D. Horizontal cable pathway locations greater than 20 cables fire stop sleeves shall be STI EZ-Path series 33.

E. Horizontal cable pathway locations fewer than 20 cables EMT sleeve with UL listed system for firestopping is acceptable. Caulks and sealants shall be as manufactured by STI, 3M, Nelson, or approved equivalent.

F. Fill ratio for fire stop EMT sleeves shall not exceed 20% fill capacity.

2.14 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-C.

2.15 IDENTIFICATION PRODUCTS

A. Comply with ANSI/TIA-606-C and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.1 INSTALLATION OF PATHWAYS

A. Comply with ANSI/TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

B. Comply with requirements in Division 26 Section "Raceways and Boxes" for installation of conduits and wireways.

C. Install manufactured conduit sweeps and long-radius elbows whenever possible.

D. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.

2. Install cable trays to route cables if conduits cannot be located in these positions.

3. Secure conduits to backboard when entering room from overhead.

4. Extend conduits 3 inches (76 mm) above finished floor.

5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.2 NON-CONTINUOUS CABLE SUPPORTS

A. Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ /TIA Standards 568 & 569, NFPA 70 (National Electrical Code), applicable local codes, and to the manufacturer’s installation instructions.

B. Do not exceed load ratings specified by manufacturer.

C. Adjustable non-continuous support sling shall have a static load limit of 100 lbs.

D. Follow manufacturer’s recommendations for allowable fill capacity for each size non-continuous cable support.

3.3 WIRING METHODS

A. Wiring Method: Install cables in raceways, J hooks, and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables accessible ceilings, walls, and floors except in unfinished spaces.

B. Install plenum cable in environmental air spaces, including plenum ceilings.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

E. Provide equipment frames and ladder racking as outlined in telecommunications series drawings.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with ANSI/TIA-568.2-D.

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Install 110-style IDC termination hardware unless otherwise indicated.

4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

10. In the communications equipment room, install a 10-foot long service loop on each end of cable.

11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with ANSI/TIA-568.2-D.

2. Do not untwist UTP cables more than 1/4 inch from the point of termination to maintain cable geometry.

3. Terminate patch panels and outlets to a pin/pair assignment as directed by owner.

D. UTP Patch Cords

1. Provide modular cords required to connect LAN switches to modular jacks on cross connect panel shall be furnished as part of this solicitation. Quantities should be equal to the total number of network outlets. At the Patch panel location provide patch cable lengths as needed for a neat installation utilizing vertical wire managers. At the user outlets provide 10 foot patch cables for each 8 pin modular connector

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.

3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. The telecom structured cable shall be supported by it’s own independent support system.

4. Plastic “zip-ties” shall not be used. Cables shall be bundled utilizing plenum rated hook an loop type cable ties.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.

2. Install cabling after the flooring system has been installed in raised floor areas.

3. Coil cable 10 feet long not less than 12 inches in diameter below each feed point.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and ANSI/TIA-569-D for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.

   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.

   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.

   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.

   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 INSTALLATION TELECOMMUNICATIONS ROOMS

A. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

B. Bond the shield of any shielded cable to the grounding bus bar in communications rooms and spaces.

3.6 FIRESTOPPING

A. General: Install through-penetration firestop systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.

B. Install EZ Path floor grid system for all Telecommunications Room floor penetrations with additional quantity as shown on contract drawings.

C. Install EZ Path Series 44 modules for all Telecommunications Room wall penetrations with additional quantity as shown on contract drawings.

D. Install EZ Path or EMT sleeve where horizontal cables penetrate a fire or smoke rated wall.

E. Manufacturer’s Instructions: Comply with manufacturer’s instructions for installation of firestopping products.

F. Comply with ANSI/TIA-569-D, "Firestopping."

G. Comply with BICSI TDMM, "Firestopping Systems" Article.

H. Any penetrations created for the passage of telecommunications which remains vacant at the completion of the installation shall be fire stopped.

3.7 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with requirements in division 26 05 26 “Grounding and Bonding for Communications Systems” for grounding conductors and connectors.

C. Comply with ANSI-J-STD-607-C.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.8 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with ANSI/TIA-606-C. Comply with requirements for identification specified in Division 26 Section “Identification for Electrical Systems."

B. For fire-resistant plywood, do not paint over manufacturer's label.

C. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an AutoCad electronic copy of final comprehensive schedules for Project.

D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of ANSI/TIA-606-C. Furnish AutoCad - latest version -electronic record of all drawings.

E. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.

3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.

4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building- mounted device shall be identified with name and number of particular device as shown.

b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in ANSI/TIA-606-C.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.9 SOURCE QUALITY CONTROL

A. Factory test UTP and optical fiber cables on reels according to ANSI/TIA-568.2-D.

B. Factory test UTP cables according to ANSI/TIA-568.2-D.

C. Factory test multimode optical fiber cables according to ANSI/TIA-526-14-A and ANSI/TIA- 568.2-D.

D. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP, multi-pair copper and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with ANSI/TIA-568.2-D.

2. Visually confirm cable category marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

a. Test instruments shall meet or exceed applicable requirements in ANSI/TIA- 568.2D. Perform tests with a tester that complies

with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. UTP Performance Tests:

   a. Test for each outlet and MUTOA. Perform the following tests according to ANSI/TIA-568.2-D:

      1) Wire map.

      2) Length (physical vs. electrical, and length requirements).

      3) Insertion loss.

      4) Near-end crosstalk (NEXT) loss.

      5) Power sum near-end crosstalk (PSNEXT) loss.

      6) Equal-level far-end crosstalk (ELFEXT).

      7) Power sum equal-level far-end crosstalk (PSELFEXT).

      8) Return loss.

      9) Propagation delay.

      10) Delay skew.

6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.

   a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

   b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or

transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

3.12 REPAIR/RESTORATION

A. Protect adjacent surfaces. Repair damage to any surfaces occurring as a result of the work of this section.

3.13 CLEANING

A. At the completion of the system, restore aspects of the project site to its former condition. Remove daily waste and excess materials, rubbish debris, tools and equipment resulting from or used in the services provided under this contract. Remove trash from all work areas. Do not use dumpsters or trash disposal without prior approval.

END OF SECTION 271000