These plans have been reviewed for code compliance by the Division of Occupational and Professional Licenses. This review shall not be construed to be an approval of any violation, or variance, from Idaho’s adopted codes, standards, laws or rules applicable to this project. Corrections will be required for any code violations found during the inspection process.

This is not a building permit

Plan Approval #:

Date:

BLD2204-00112

05/31/22

APRIL 20, 2022

DESIGN SPECIFICATIONS

PERMIT
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DIVISION 22 – PLUMBING

SECTION 220000 – PLUMBING GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE:
   A. General:
      1. The Bidding Requirements, Contract Requirements, and the General Requirements (Division
         01) of these specifications shall govern all parts of the work.
   B. Work Included:
      1. Install work in accordance with these specifications and the accompanying plans. Furnish all
         labor, material, and equipment together with all incidental items not specifically shown or
         specified which are required by good practice to provide the complete plumbing systems as
         described.
   C. Coordination and Site Visits:
      1. This section of the work requires examination of and reference to all architectural, structural,
         utility, and electrical drawings for construction conditions that may affect the work. Inspect
         the building site and existing facilities for verification of existing conditions. Base all
         measurements from established benchmarks. Any discrepancy between actual measurements
         and those indicated, which prevents following good practices or the intent of the drawings
         and specifications, shall be reported to the Architect/Engineer, and work halted until
         instructions are received from the Architect/Engineer.

1.2 CODES, PERMITS, FEES:
   A. Install all work in accordance with applicable codes and standards. Obtain all required permits; pay
      all required fees including utility connections or extensions, in connection with this portion of the
      construction. Obtain all required certificates of inspection for the work.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP:
   A. Materials:
      1. All materials and equipment shall be of first quality, new, full size and weight, standard in
         every respect, and suitable for the space required. Use the same manufacturer for products of
         similar class or service, such as valves and pumps. Protect all materials against loss, theft, or
         damage before and after installation.
2. Furnish and install all necessary foundations, supports, pads, bases, and piers required for all materials and equipment furnished under this contract.

3. Provide all required firestopping at piping penetrations of fire rated walls, floors, ceilings, and roofs. Firestopping shall be Dow Corning Fire Stop Sealant 2000 or Fire Stop Foam 2001, or approved equal.

4. Provide a heat-expanding fire collar for all non-metallic piping up to 6” size at penetrations of fire rated walls, floors, and ceilings per ASTME 814.

B. Workmanship:

1. All materials and equipment shall be installed in a neat and workmanlike manner by competent specialists for each subtrade. Work shall be installed to the satisfaction of the Architect/Engineer with unsatisfactory work removed and reinstalled to his satisfaction at no extra cost to the Owner.

2. Provide all cutting and patching necessary to install the work specified in this section. Patching shall match adjacent surfaces. No structural members shall be cut without the approval of the Architect/Engineer. Provide all sleeves and inserts required before the floors and walls are built.

3. Locate all equipment that must be serviced in fully accessible positions. Provide clearance for removal of replacement parts and components, and with necessary couplings or flanges to remove the component for maintenance.

2.2 SUBMITTALS AND SUBSTITUTIONS:

A. Prebid Approval:

1. Manufacturer’s trade names and catalog numbers stated herein are intended to indicate the quality of equipment or materials desired. All manufacturers not specifically listed require prior approval. Submit catalog data, including specifications, of the proposed equipment to the Architect/Engineer for his approval at least 10 calendar days prior to bid opening. Notice of such approvals will be published in an addendum. Approval of listed alternate equipment manufacturers is for bidding only. Final approval is to be based on requirements of the plans and specifications.

B. Submittals:

1. Within thirty days after award of this contract, provide an electronic copy of a complete list of all materials and equipment proposed for this project. List shall contain make, type, manufacturer's name, and trade designation of all materials and equipment. Submittal shall also include manufacturer's complete specification for each item, including ratings, and dimensions as required to check space requirements. The scheduled equipment is the basis of design for physical size, etc. Alternate manufacturers shall not exceed the weight or physical size. Any changes to the Architectural, Structural and Mechanical systems due to alternate manufactures shall be the responsibility of the Contractor and Supplier. Submittals for fixtures, trim, and other plumbing related items, requiring submittals, shall be submitted in a single complete package. Individual items will not be reviewed independently unless
approved by the Engineer.

2. Approval of submittals shall not relieve the contractor from responsibility for deviations from the plans or specifications, unless he has, in writing, called the Architect's/Engineer's attention to deviations at the time of submission, and obtained his written approval. Approval of submittals does not relieve the contractor from responsibility for errors in shop drawings or literature.

C. Equipment Requiring Submittals:

1. Plumbing Fixtures & Trim
2. Valves
3. Cast Iron Soil Piping
4. Pipe Stands

PART 3 - EXECUTION

3.1 ACCESSIBILITY & SAFETY:

A. Accessibility:

1. All equipment which must be serviced or operated shall be located in fully accessible position. Minor changes from the drawings may be made to allow for better accessibility. All changes shall be approved prior to actual installation.

2. Access panels shall be provided if required for accessibility. Access panels to be steel, flanged, hinged doors by Cendrex, model AHD, or equal. Size as required for installation. Subcontractor shall furnish the required panels to the General Contractor and the required location for all access panels, unless otherwise specified in the Architectural specifications. Panels shall be installed by the General Contractor.

B. Safety:

1. No water piping shall run immediately over or within a 3-foot plan view clearance of any electrical panel or motor starter. Where piping must be located within these zones, install piping inside a conduit to prevent water access to electrical equipment.

3.2 COORDINATION:

A. Coordinate all work with the various trades involved to provide a complete and satisfactory installation. The exact details of piping and equipment are not shown. No additional compensation will be made for offsets or relocation required in coordination with other trades.

B. Alterations required due to improper supervision by the subcontractor shall be made at no extra cost, to the satisfaction of the Architect/Engineer.
3.4 IDENTIFICATION AND CODING:

A. General:
   1. The Contractor shall use ASME 13 standards for all piping identifications, color coding, and compliance.

B. Painting:
   1. All painting of equipment, accessories, and piping shall be furnished and applied under the Architectural section of these specifications. All painting shall be completed before any identification markings are applied.

C. Piping:
   1. Identify all piping as to the service of the pipe and the direction of flow. The letters shall be 3/4 inch high on piping two inches or smaller, and 1-1/4 inches high on piping up to six inches. Flow arrows shall be at least six inches long. The letters and flow arrows shall be made by precut stencils and oil base paint, one inch high and black, or factory fabricated plastic pipe markers. Piping shall be identified at 25 foot maximum intervals, on long continuous lines; adjacent to each item of equipment; on each riser and junction, and on both sides of all wall penetrations. Underground piping shall be identified with bright colored continuously printed plastic tape of not less than 6" wide by 4 mil thick, manufactured for direct burial service. Install directly above all buried pipe, 6 to 8 inches below finished grade.

D. Valves:
   1. Regardless of size, all valves shall be tagged with a numbered brass tag, 1-1/2 inches by 3 inches minimum in size and 0.051 inch thick. A valve chart indicating valve tag number, location, service, and normal position shall be mounted in a suitable framed and glassed cover in the main mechanical room or as directed. Valve chart shall be duplicated in the Maintenance and Operations Manual.

3.5 TESTING:

A. Piping:
   1. All plumbing piping gas shall be tested in accordance with the requirements of local adopted plumbing code, latest edition. Other piping systems shall be tested hydrostatically to 1.5 times the operating pressure but not less than 100 psi, for a minimum period of two hours. If the test pressure falls more than 5 percent during the test period, the leak shall be located, repaired, and the test repeated.

   2. Piping shall be tested before insulation has been installed. Delicate control mechanisms shall be removed during tests to prevent shock damage. The use of chemicals or compounds to stop leaks shall not be permitted.

   3. A test report shall be submitted for each piping system test. Test report forms are part of Specifications Section 220100, or are available from the Engineer.
B. Systems:

1. All plumbing systems shall be tested at the completion of the building to establish that the systems operate as specified and required.

3.6 CLEANING AND ADJUSTING:

A. Thoroughly clean all parts of the system at the completion of the work. Flush all water circulating systems with fresh water and then drain. Clean all strainers and refill system. Adjust all devices for proper operation and lubricate all equipment as required. Repaint any painted surface that has been damaged.

3.7 PROJECT CLOSEOUT:

A. Operations & Maintenance Manual:

The Contractor shall provide an operations and maintenance manual at least thirty days prior to completion of work. The manual shall be of the three ring binder type, entitled "Operations and Maintenance Manual", with the job name and year of completion also included. O & M manuals shall be submitted in a single package. Individual items will not be accepted independently unless approved by the Engineer. The manual shall include, as a minimum:

1. Maintenance instructions for all equipment, including lubrication requirements.
2. Fixture suppliers names, addresses, and telephone numbers.
3. Fixture catalog cuts, ratings tables, model numbers, serial numbers, and accessories.
4. Parts numbers for all replaceable parts.
5. Valve tagging chart as hereinbefore specified.
7. Any additional information required to enable the Owner to properly maintain the building plumbing system.
8. After approval of the Operations and Maintenance Manual by the Architect/Engineer, the Contractor shall furnish two copies of the manual to the Owner.

B. As-Built-Drawings:

1. Provide two sets of red-line mechanical drawings showing the work as it was actually installed. The drawings shall indicate all departures from the contract drawings and shall locate all underground utility lines with dimensions from established building lines. Make all notations neat and legible, with red indelible pencil. At the completion of the work, these as-built drawings shall be signed and dated by the Plumbing Contractor and returned to the Architect/Engineer.

C. Guarantee:
1. All work furnished under this section shall be guaranteed in writing to be free from defective work or materials for a period of one year after acceptance of the contract. All repairs or replacements because of defective materials or workmanship or noncompliance with code shall be provided without additional cost to the Owner. Contractor shall furnish a letter indicating above guarantee with space for date of acceptance and expiration of guarantee. Letter shall be included in O & M Manual.
SECTION 220100 - PLUMBING

PART 1 - GENERAL

1.1 SCOPE:
A. This section covers the work necessary for the plumbing system, complete. The Plumbing General Requirements, Section 220000, are to be included as a part of this section of the specifications.

1.2 CODES:
A. The plumbing system shall be installed in accordance with the requirements of local adopted plumbing code, latest edition, International Fuel Gas Code, latest edition; and all local and State Codes.

PART 2 – PRODUCTS

2.1 PIPING AND FITTINGS:
A. General:
   1. Connections between piping of dissimilar materials shall be made with dielectric waterway fittings or unions.
B. Natural Gas:
   1. Piping shall be Schedule 40 black steel pipe, ASTM A53. Exposed fittings 2 inches and smaller shall be ANSI/ASME B16.3, screwed, black malleable iron.
   2. Fittings larger than 2 inches and all underground fittings shall be Schedule 40 steel butt-welded type. Underground piping shall be provided with a polyethylene jacket, ANSI/AWWA C105, or shall be wrapped with double layer, half-lapped, 10 mil polyethylene tape.
      a. Contractors Option for Underground Pipe:
         2) Piping and fittings underground and outside the building line may be JM Eagle UAC 2000 MDPE, medium-density polyethylene yellow gas pipe or an approved equal. Piping shall be installed in accordance with JM Eagle Publication JME-12B, “Polyethylene Yellow Gas Distribution Installation Guide.” JM Eagle’s UAC 2000 system can be joined by butt heat fusion, socket fusion, or saddle fusion. Installing contractor shall be licensed for fusion pipe installation of polyethylene pipe. ASTM D2513.
   3. All exterior piping exposed to the weather shall be coated with a rust inhibitor – Rustoleum #866 Pro-Guard Primer – yellow or gray color – or approved equal.
C. Condensate Drain Piping:

1. Exterior to building (connected to roof mounted equipment): Piping shall be Schedule 40 PVC. A union shall be installed directly at the roof top equipment for ease of replacement in the future.

PART 3 - EXECUTION

3.1 WORKMANSHIP:

A. General:

1. Install all piping, fixtures, equipment, and accessories as shown, and in strict accordance with the plumbing laws, rules, and regulations of the State and/or City. All work shall be done in a neat and orderly fashion and left in a condition satisfactory to the Architect/Engineer.

B. Piping:

1. All piping shall be run parallel or perpendicular to established building lines. Install piping so as to allow for expansion. Waste and vent piping occurring above floor slab shall be installed true and plumb. Extend vents at least 1 foot above roof, or to the top of the closest adjacent parapet wall, whichever is greater, and provide watertight flashing sleeves. Excavation and backfill shall be in accordance with Section 220000 of these specifications.

C. Fixtures:

1. Install fixtures true and plumb with building walls. Caulk all plumbing fixtures at joints along walls, countertops, and other intersecting surfaces. Locate fixtures as shown and per manufacturer's instructions. Furnish all required trim for fixtures to provide a complete and workable installation.

END OF SECTION 220100
DIVISION 23 – HEATING VENTILATING AND AIR CONDITIONING

SECTION 230000 - HVAC GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE:

A. General:

1. The Bidding Requirements, Contract Requirements, and the General Requirements (Division 1) of these specifications shall govern all parts of the work.

B. Work Included:

1. Install work in accordance with these specifications and the accompanying plans. Furnish all labor, material, and equipment together with all incidental items not specifically shown or specified which are required by good practice to provide the complete mechanical systems as described.

2. The HVAC Contractor(s) and all Sub-tier Contractors shall provide installed equipment cut sheets and purchase orders required for utility rebates.

C. Coordination and Site Visits:

1. This section of the work requires examination of and reference to all architectural, structural, utility, and electrical drawings for construction conditions that may affect the work. Inspect the building site and existing facilities for verification of existing conditions. Base all measurements from established benchmarks. Any discrepancy between actual measurements and those indicated, which prevents following good practices or the intent of the drawings and specifications, shall be reported to the Architect/Engineer, and work halted until instructions are received from the Architect/Engineer.

1.2 CODES, PERMITS, FEES:

A. Install all work in accordance with applicable codes and standards. Obtain all required permits; pay all required fees including utility connections or extensions, in connection with this portion of the construction. Obtain all required certificates of inspection for the work.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP:

A. Materials:

1. All materials and equipment shall be of first quality, new, full size and weight, standard in

HVAC GENERAL REQUIREMENTS
every respect, and suitable for the space required. Use the same manufacturer for products of similar class or service, such as valves, pumps, controls, and air handlers. Protect all materials against loss, theft, or damage before and after installation.

2. Furnish equipment that will operate under all conditions of load without any sound or vibration that is objectionable in the opinion of the Architect/Engineer. Vibration or noise considered objectionable will be corrected by the Subcontractor at his expense.

3. Furnish and install all necessary foundations, supports, pads, bases, and piers required for all materials and equipment furnished under this contract.

4. Provide all required firestopping at duct penetrations of fire rated walls, floors, ceilings, and roofs. Firestopping shall be Dow Corning Fire Stop Sealant 2000 or Fire Stop Foam 2001, or approved equal.

B. Workmanship:

1. All materials and equipment shall be installed in a neat and workmanlike manner by competent specialists for each subtrade. Work shall be installed to the satisfaction of the Architect/Engineer with unsatisfactory work removed and reinstalled to his satisfaction at no extra cost to the Owner.

2. Provide all cutting and patching necessary to install the work specified in this section. Patching shall match adjacent surfaces. No structural members shall be cut without the approval of the Architect/Engineer. Provide sleeves at all piping penetrations of exterior walls and floors on grade. Provide all sleeves and inserts required before new floors and walls are built.

3. Locate all equipment that must be serviced in fully accessible positions. Provide clearance for removal of replacement parts and components, and with necessary couplings or flanges to remove the component for maintenance.

C. Protection of Equipment During Construction:

1. At the end of each shift, all duct openings and open ends shall be covered with a plastic poly sheeting film to protect against dust and construction contamination from entering the ductwork.

2.2 SUBMITTALS AND SUBSTITUTIONS:

A. Prebid Approval:

1. Manufacturer’s trade names and catalog numbers stated herein are intended to indicate the quality of equipment or materials desired. All manufacturers not specifically listed require prior approval. Submit catalog data, including specifications, of the proposed equipment to the Architect/Engineer for his approval at least 10 calendar days prior to bid opening. Notice of such approvals will be published in an addendum. Approval of listed alternate equipment manufacturers is for bidding only. Final approval is to be based on requirements of the plans and specifications.
B. Submittals:

1. Within thirty days after award of this contract, provide an electronic copy of a complete list of all materials and equipment proposed for this project. List shall contain make, type, manufacturer's name, and trade designation of all materials and equipment. Submittal shall also include manufacturer's complete specification for each item, including capacities, ratings, etc., and dimensions as required to check space requirements. The scheduled equipment is the basis of design for capacity, weights, physical size, etc. Alternate manufacturers shall not exceed the weight or physical size. Any changes to the Architectural, Structural, Mechanical, Electrical, and Control systems due to alternate manufactures shall be the responsibility of the Contractor and Supplier. Submittals for each major trade (i.e., dryside HVAC, wetside HVAC, or Plumbing) shall be submitted in a single complete package. Individual items will not be reviewed independently unless approved by the Engineer.

2. Approval of submittals shall not relieve the contractor from responsibility for deviations from the plans or specifications, unless he has, in writing, called the Architect's /Engineer's attention to deviations at the time of submission, and obtained his written approval. Approval of submittals does not relieve the contractor from responsibility for errors in shop drawings or literature.

C. Equipment Requiring Submittals:

1. Rooftop Units
2. Controls
3. Curb Adapters

PART 3 - EXECUTION

3.1 ACCESSIBILITY & SAFETY:

A. Accessibility:

1. All equipment which must be serviced or operated shall be located in fully accessible position. Minor changes from the drawings may be made to allow for better accessibility. All changes shall be approved prior to actual installation.

2. Access panels shall be provided if required for accessibility. Access panels to be steel, flanged, hinged doors by Cendrex, or equal. Sized as required for installation. Subcontractor shall furnish the required panels to the General Contractor and the required location for all access panels, unless otherwise specified in the Architectural specifications. Panels shall be installed by the General Contractor.

B. Safety:

1. Subcontractor shall provide guards for all belt drives and rotating machinery.
3.2 COORDINATION:

A. Coordinate all work with the various trades involved to provide a complete and satisfactory installation. The exact details of ductwork and equipment are not shown. No additional compensation will be made for offsets or relocation required in coordination with other trades.

B. Alterations required due to improper supervision by the subcontractor shall be made at no extra cost, to the satisfaction of the Architect/Engineer.

3.3 ELECTRICAL:

A. Electric motors required for equipment specified in this section shall be provided and installed by this Subcontractor. Motor starters, disconnects, relays, pilot lights, etc., are in general, to be furnished and installed by the Electrical Contractor. Starters, relays, controls, etc., which are factory assembled into packaged equipment shall be furnished by the Mechanical Contractor under this section of the specifications.

B. All motors shall be provided with adequate starting and protective equipment as specified or required. Motor capacity shall be sufficient to operate driven device under all conditions of operation and load without overload. Minimum horsepower shall be as specified.

3.4 IDENTIFICATION AND CODING:

A. Painting:

1. All painting of mechanical equipment, accessories and ductwork shall be furnished and applied under the Architectural section of these specifications. All painting shall be completed before any identification markings are applied.

B. Equipment:

1. Identify all equipment with a black Formica label, with white reveal when engraved. Lettering to be 3/16 inch high minimum. In general, identify equipment as to area served in addition to title and code number of the equipment as taken from the plans.

C. Piping:

1. Identify all piping as to the service of the pipe and the direction of flow. The letters shall be 3/4 inch high on piping two inches or smaller, and 1-1/4 inches high on piping up to six inches. Flow arrows shall be at least six inches long. The letters and flow arrows shall be made by precut stencils and oil base paint, one inch high and black, or factory fabricated plastic pipe markers. Piping shall be identified at 25 foot maximum intervals, on long continuous lines; adjacent to each item of equipment; on each riser and junction, and on both sides of all wall penetrations. Underground piping shall be identified with bright colored continuously printed plastic tape of not less than 6" wide by 4 mil thick, manufactured for direct burial service. Install directly above all buried pipe, 6 to 8 inches below finished grade.

3.5 TESTING:
HVAC GENERAL REQUIREMENTS

A. Systems:
   1. All systems, including heating, ventilating and air conditioning, shall be tested at the completion of the building to establish that the systems operate as specified and required. Testing shall be performed after air balancing is completed.
   2. All controls shall be calibrated accurately and all equipment shall be adjusted for satisfactory operation. Excessive vibration or noise from any system shall be corrected.
   3. The air conditioning system shall be tested for satisfactory operation when the outside air temperature reaches 60 degrees F. or warmer. All other systems shall be tested at building completion. All tests shall be performed in the presence of the Architect/Engineer or his representative.

3.6 BALANCING:

A. Scope:
   1. Prior to final acceptance by the Owners, all air systems shall be balanced to deliver the quantities as specified or directed. The air balance shall be performed by an independent agency specializing in balancing and is certified by the National Environmental Balancing Bureau.
   2. Balance contractor’s main office shall be located within 50 miles from the project site. Approved balance contractors are NWESI, Building Systems Technologies, and Blue-Sky Commissioning. All other contractors must receive prior approval from the Engineer, in writing, before bidding the project.
   3. The Mechanical Contractor shall provide assistance to the Balancing Contractor by identifying all installed mechanical systems and assisting access to all installed mechanical systems. All mechanical systems shall be completely operational and functional prior to the Balancing Contractor performing their specified work.

B. Air balancing:
   1. Balancing of the air system shall consist of:
      a. Contractor shall test the supply main and return mains to verify airflow.
      b. Record all system CFM.
      c. Test and record all system static pressures, inlet and discharge, on all packaged units.
      d. Test and record motor full load amps and nameplate amps.
      e. Test and record entering and leaving temperatures at all rooftop units.

C. Quality Assurance:
   1. The Balancing Contractor shall demonstrate to the Engineer of record, flow verification for at least 10% of the balanced devices as selected by the Engineer. If more than 25% of the tested devices do not meet the designed or balance report, then the entire system balance must be rebalanced.

D. Balance Reports:
1. Submit four copies of the air system balance report to the Architect/Engineer for evaluation and approval. Reports shall be on TABB/SMACNA forms that indicate information addressing each of the testing methods, readings, and adjustments.

3.7 CLEANING AND ADJUSTING:

A. Thoroughly clean all air conditioning units, air handling units, and all associated parts of the system at the completion of the work. Install new, clean air filters in all systems. Adjust all devices for proper operation and lubricate all equipment as required. Repaint any painted surface that has been damaged.

3.8 PROJECT CLOSEOUT:

A. Operations & Maintenance Manual:
   The Contractor shall provide an operations and maintenance manual at least thirty days prior to completion of work. The manual shall be of the three-ring binder type, entitled "Operations and Maintenance Manual", with the job name and year of completion also included. O & M manuals shall be submitted in a single package. In addition, the contractor shall provide two consolidated electronic versions on two separate thumb drives. Individual items will not be accepted independently unless approved by the Engineer. The manual shall include, as a minimum:

1. Maintenance instructions for all equipment, including lubrication requirements.
2. Equipment suppliers’ names, addresses, and telephone numbers.
3. Equipment catalog cuts, ratings tables, model numbers, serial numbers, and accessories.
4. Parts numbers for all replaceable parts.
5. Air systems balance report as hereinbefore specified.
6. Control diagram or drawing and operation sequence.
7. Valve tagging chart as hereinbefore specified.
8. Filter chart listing unit callout, size of filters, and quantity of filters.
9. Guarantee letter as specified below.
10. Any additional information required to enable the Owner to properly maintain the building mechanical system.
11. Mechanical Equipment Start-up forms, which are included in this specification, if they are required.
12. After approval of the Operations and Maintenance Manual by the Architect/Engineer, the Contractor shall furnish two copies of the manual to the Owner.

B. Mechanical System Training Period:
1. After the mechanical system is completely installed and operational, the mechanical contractor shall provide a minimum of 4 hours training and instruction time for the building Owner or his representative. During this period, the contractor shall instruct the Owner in the operation and maintenance of all parts of the mechanical system, using the O & M manual where applicable. The contractor shall provide a copy of the Project Owner Mechanical Systems Training Form (attached to this specification), with proper signatures, to the Engineer prior to substantial completion and ensure that a copy is inserted into the project O & M manuals.

2. **OPTION:** Video Taping – The mechanical contractor is to perform videotaping of the Owner training and instruction. Provide two (2) CD copies to Owner and one (1) copy to be inserted into the O & M Manuals.

C. As-Built-Drawings:

1. Provide two sets of red-line mechanical drawings showing the work as it was actually installed. The drawings shall indicate all departures from the contract drawings. Make all notations neat and legible, with red indelible pencil. At the completion of the work, these as-built drawings shall be signed and dated by the Mechanical Contractor, and returned to the Architect/Engineer.

D. Guarantee:

1. All work furnished under this section shall be guaranteed in writing to be free from defective work or materials for a period of one year after acceptance of the contract. All repairs or replacements because of defective materials or workmanship or noncompliance with code shall be provided without additional cost to the Owner. Contractor shall furnish a letter indicating above guarantee with space for date of acceptance and expiration of guarantee. Letter shall be included in O & M Manual.

END OF SECTION 230000
NAME OF PROJECT: ________________________________

____________________________________________

OWNER MECHANICAL SYSTEM TRAINING FORM

Upon completion of the equipment and systems installation and connections, the contractor shall assemble all required equipment factory representative and subcontractors together for system Owner training.

These people shall assist in Owner training their system(s) and remain at the site until the total system operations is acceptable and understood by the Owner’s representative(s), maintenance and/or operation personnel, on operation and maintenance of their equipment. To prove acceptance of operation and instruction by the Owner’s representative(s), the contractor shall provide a copy of this form, with proper signatures, to the Engineer prior to substantial completion, and ensure that a copy is inserted into the project Operation and Maintenance manuals.

“I, the Contractor, associated factory representative and subcontractors, have started each system and the total system(s); and have proven their normal operation to the Owner’s representative(s) and maintenance/operation personnel and have instructed him/them __________, hours in the operation and maintenance thereof.”

__________________________________  __________________________________
Owner’s Representative  Contractor

__________________________________  __________________________________
Signature  Signature

__________________________________  __________________________________
Date  Date
SECTION 230100 - HEATING, VENTILATING, AND AIR CONDITIONING

PART 1 - GENERAL

1.1 SCOPE

A. This section covers the work necessary for the heating, ventilating, and air conditioning system, complete. The HVAC General Requirements, Section 230000, is to be included as a part of this section of the specifications.

1.2 CODES & STANDARDS

A. The heating, ventilating, and air conditioning system shall be installed in accordance with the latest edition of the following codes and standards:

1. International Mechanical Code (IMC)
2. International Building Code (IBC)
3. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
4. National Fire Protection Association (NFPA)
5. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

PART 2 - PRODUCTS

2.1 AIR HANDLING UNITS AND APPURTEANCES

A. Packaged Rooftop Air Conditioning Unit:

1. General:
   a. The packaged unit shall consist of condensing section, evaporator section, heating section, blower, filter, and controls, all contained in weatherproof casing suitable for installation on the roof. The entire unit is to be factory wired, piped, and tested. Unit shall bear the UL label for the intended application.

2. Casing:
   a. Casing shall consist of welded steel reinforced framework with 18-gauge zinc grip steel finished with weatherproof baked enamel paint. Cooling section shall be insulated with minimum 1" thick, 1.5 density coated sound absorbing insulation. Easily removable panels shall be provided for access to internal components.

3. Condensing Section:
   a. Condensing section shall include spring mounted hermetic compressors; air cooled
condenser and fans, evaporator coil, and refrigeration piping and specialties. Compressors shall be furnished with current and temperature overload protection, oil sight glass, and shall carry a 5-year guarantee. Condenser fans shall be upflow propeller type with direct or belt drive motors with overload protection. Propeller fans shall be coated with weather resistant finish and protected by fan guard. Evaporator coils shall be direct expansion coils complete with thermostatic expansion valves. Furnish galvanized drain under coil. Refrigerant piping system shall be completely factory piped with a full operating charge of R-410a. Suction line to be insulated. Units shall be furnished with low ambient control, for operation down to 0 degrees F (not required on units furnished with economizers).

4. Gas Heating Section:
   a. Gas heating section shall be AGA certified and include gas fired furnace with steel heat exchanger and burners, power vent, manual main and pilot shutoff valves, automatic gas valve, electronic ignition, and flame proving controls. Entire unit shall be tested and certified for operation down to -30 degrees F. outdoor temperature.

5. Blower:
   a. Blower section shall consist of heavy duty, centrifugal blower wheels, balanced to eliminate vibration. Furnish adjustable motor mount and v-belt drive. Motors shall be furnished with overload protection.

6. Filters:
   a. Filters for units 2 ½ tons or smaller shall be 1 inch thick replaceable pleated media type, rated at MERV 8.
   b. Filters for units 3 ton and above shall be 2 inch thick replaceable pleated media type, rated at MERV 8. Provide with 2 inch filter rack.
   c. Provide 4 extra sets of filters per unit.

7. Control Section:
   a. Controls shall include a factory installed control circuit transformer, starters, 3-leg overload protection, high and low pressure refrigerant controls, and terminal strip for connection of remote controls.
   b. Unit shall be shipped ready for DDC controller for onsite installation. Unit shall be shipped with not unit controls – control diagrams for requirements.

8. Manufacturer, Capacity and Accessories:
   a. See drawings.

2.2 AIR DISTRIBUTION

A. Ductwork:
   1. Low pressure ductwork shall be fabricated from galvanized sheet metal, unless otherwise indicated. Construction requirements shall be in accordance with SMACNA - HVAC Duct Construction Standards, metal and flexible, latest edition. All sheet metal ductwork shall be sealed with McGill United Sheet Duct Sealer or equal, in accordance with the International Energy Compliance Code, latest edition. Adjustable (twist) elbows are not allowed. Low pressure ductwork shall be constructed to the following SMACNA static pressure standards:
a. Supply air ductwork = 2" W.G.
b. Return, Exhaust, Outside Air Intake ductwork = 1" W.G.

B. Duct Accessories:

1. Turning vanes shall be installed in all rectangular or square elbows. Vanes shall be installed in vane side rails. Vanes shall be single wall vanes, and be fabricated and installed per SMACNA standards.

2. Flexible connections shall be provided at all rotating fan equipment. Connectors shall be of fire, water, and weather resistant material.

C. Duct Cleanliness:

1. Ductwork Delivery To Site
   a. During ductwork being delivered from the premises of the manufacturer, care must be taken to prevent damage during transportation and off-loading.

2. Temporary Storage
   a. Job site duct material storage areas should be clean, dry, and located away from high dust generating processes such as masonry or tile cutters, cutoff saws, drywall sanding, mortar and plaster mixers, roof pitch kettles, portable electric generators, and main walkways that will be constantly broom swept. The general contractor should designate a suitable area for temporary storage.
   b. To prevent ductwork material damage from standing water, storage locations should include pallets or blocking to keep fabricated metal ductwork above the floor surface. If there is a risk of water runoff from above or dusty areas cannot be avoided, coverage should be used to protect stored materials.

3. Installation
   a. Before the installation of individual duct sections, they are to be inspected to ensure that they are free from all debris.
   b. All ductwork risers must be covered to prevent the entry of debris into the duct.
   c. Downward facing and horizontal ductwork openings will not be required to be covered.
   d. Access covers shall be firmly fitted in position on completion of each section of the work. Open ends on completed ductwork and overnight work-in-progress shall be sealed.
   e. The working area should be clean and dry and protected from the elements.
   f. The internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation.

2.3 CONTROL SYSTEM

A. General:

1. The Control Contractor shall be responsible for a complete and operable control system, including equipment, installation, and accessories required to perform the functions specified on the drawings. The Control Contractor shall supervise the installation of all control
equipment and accessories and shall submit shop drawings of the proposed system for approval.

2. The Control Contractor shall furnish and install all control conduit and wiring. All wiring shall be installed in EMT in accordance with the section Electrical. Provide plastic covered wires of not less than 18-gauge (16-gauge if longer than 50’), with at least one spare circuit at each control device. Control voltage shall not exceed 30 volts, except in starter pilot circuits.

3. The Mechanical Contractor shall be responsible for installing all control valves, water flow switches, temperature wells, control dampers, and related equipment which is furnished by the Control Contractor.

5. The Control Contractor shall be a contractor who is regularly engaged in control system work, and can furnish a verified list of satisfactory installations of this type and size, for a period of 5 years or more.

B. Control Equipment and Accessories:

1. Equipment Control Schematics:
   a. See Drawings for schematics and sequence of operations.

PART 3 - EXECUTION

3.1 WORKMANSHIP

A. General:

1. Install all materials and equipment as shown and in strict accordance with the applicable codes for the State and/or city. Plans do not attempt to show exact details of all piping and ductwork, and no extra payment will be allowed for offsets required due to obstructions by other trades. All work shall be done in a neat and orderly fashion and left in a condition satisfactory to the Architect/Engineer.

2. All piping shall be run parallel or perpendicular to established building lines. Install piping so as to allow for expansion. Install all valves with stems horizontal or above. Install air vents at all high points. Provide all piping which passes through walls, floors, or ceilings with standard weight pipe sleeves.

B. Ductwork:

1. All sheet metal work shall be done by qualified, experienced mechanics in accordance with the requirements of ASHRAE and the latest edition of the applicable SMACNA Manual. All ductwork shall be installed in a neat and orderly manner, and shall be adequately supported to prevent vibration or sagging. All sheet metal ductwork shall be sealed with United-Sheet Metal Duct Sealer or equal.

END OF SECTION 230100
SECTION 230150 - MECHANICAL START-UP

PART 1 - GENERAL

1.1 SCOPE:

A. General:

1. The purpose of the mechanical start-up is to provide the owner of the facility with a high level of assurance that the mechanical system has been installed and operates per the requirements of the mechanical construction plans and specifications. The Mechanical General Provisions, Section 230000, is to be included as a part of this section of the specifications.

B. Pre-start and Start-up checklist:

1. The contractor shall be responsible for the completion of pre-start and start-up checklist forms. These forms can usually be obtained from the equipment manufacturer. If the forms cannot be obtained from the manufacturer, forms may be obtained from the Engineer.

2. After completion of pre-start and start-up checklists, the contractor shall provide a copy of the pre-start and start-up checklist to the engineer for review and approval prior to substantial completion.

3. Approved Mechanical Equipment Start-up forms shall be included in the operations and maintenance manual.

PART 2 – START-UP PROCESS

2.1 RESPONSIBILITIES

A. Mechanical Contractor:

1. Coordinate with other trades involved in the installation of mechanical equipment to complete the requirements of mechanical start-up specifications.

2. Complete the pre-start and start-up checklist forms obtained from the equipment manufacturer or the Engineer.

3. Notify the mechanical engineer of tests to be witnessed. Contractor shall give the engineer a minimum of 48 hours notice prior to test.

B. Engineer:

1. Review the completed pre-start and start-up check lists provided by the mechanical contractor.

2. At final inspection, spot check items on the pre-start and start-up checklist forms to ensure
that they have been completed.

2.2  EQUIPMENT PRE-START

A.  Before starting any equipment or system, complete the system pre-start checklist forms. As part of the pre-start process, the following items shall be completed as applicable:

1.  Piping systems shall be pressure tested as specified, found to be tight, with reports submitted.

2.  Piping systems shall be flushed and cleaned as specified, all required reports submitted, and the system shall be filled or charged per plans.

3.  Air system cleaning is complete and final filters shall be installed.

4.  Vibration isolation and seismic restraints shall be installed per plans and specifications.

5.  Equipment drives shall be aligned.

6.  Electrical services shall be installed and checked.

7.  Control points checkouts shall be completed.

8.  Safety controls shall be installed and operation checked.

9.  Manufacturer’s representatives have carried out major equipment start-up, and all checks shall be documented on the relevant checklists as they are carried out.

10. Equipment has been thoroughly cleaned (interior and exterior of units), of construction debris.

11. Deficiencies or incomplete work shall be corrected and pre-start shall be repeated until the installation is ready for operation.

2.3  EQUIPMENT START-UP

A.  After the pre-start up process described in Section 2.2, complete the system start-up checklist and document findings with forms provided. As part of the Start-up process, the following items shall be completed as applicable:

1.  Air systems balanced as specified in plans and specifications.

2.  Water systems balanced as specified in plans and specifications.

3.  Problems revealed during balancing of air and water systems shall be corrected.

4.  All automatic temperature controls devices shall be calibrated, including adjustments to control valves and damper actuators.

5.  Set up or program controls for accurate response and precise sequencing to meet specified performance.
6. The controls contractor and balancing contractor shall adjust and set air flows and calibrate controls of equipment as applicable.

7. Ensure final adjustments to vibration isolation and seismic restraints are carried out per the manufacturer’s requirements.

8. Check the operation of all fire dampers; smoke dampers and combination fire/smoke dampers.

B. Deficiencies or incomplete work shall be corrected, and the startup shall be repeated until correct installation and function has been confirmed and the installation is ready for engineer verification.

2.4 TRAINING AND INSTRUCTION

A. Once the substantial completion has been approved, the mechanical contractor shall provide the Owner and engineer with a training schedule for operation of the mechanical equipment and systems and their controls as listed in the specifications and plans. Reference Section 230000 Mechanical General Provisions, “Project Closeout” of these specifications.

PART 3 – EXECUTION

A. The following systems and equipment shall be completed under the mechanical start-up plan as described above and documented with equipment pre-start and start-up forms provided.

1. Packaged Rooftop Units
2. Exhaust Fans
3. Ductless Split Systems
4. Energy Recovery Unit
5. Digital Controls
6. Electric Heaters

B. Pre-start and start-up forms are to be provided to the engineer for final approval before substantial completion.

C. Approved forms shall be included in the operations and maintenance manual.

END OF SECTION 230150
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.

B. Scope:
   1. The Contractors shall work and assist the Commissioning Agent in the commissioning process. Refer to sections 011913 and 230816 for additional requirements.

1.2 DEFINITIONS

A. AABC: The Associated Air Balance Council, a nonprofit association of certified, independent test and balance agencies.

B. NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems

C. T&B: Testing, adjusting, and balancing

D. T&B Agency: An independent entity certified by AABC and/or NEBB to perform testing and balancing work

E. TBE: AABC and/or NEBB certified test and balance engineer

F. TBT: AABC and/or NEBB certified test and balance technician

G. HVAC: Heating, ventilating, and air conditioning

H. BAS: Building automation systems

1.3 SUBMITTALS

A. Qualifications: Within 30 days of Contractor's Notice to Proceed, submit qualifications of AABC and/or NEBB agency and personnel, including a sample copy of the National Performance Guaranty.


C. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, Balancing Contractor shall provide system readiness checklists as specified in Section 3.2, “Preparation,” to be used and filled out by the installing contractors verifying that systems are ready for T&B.
D. Examination Report: Provide a summary report of the examination review required in Section 3.1, if issues are discovered that may preclude the proper testing and balancing of the systems.

E. Certified T&B report: Within 14 days of completion of balancing work, submit AABC or NEBB certified T&B report.

1.4 QUALITY ASSURANCE

A. Agency Qualifications: An independent T&B agency certified by AABC and/or NEBB

   1. Supervisor: Employee of the T&B agency who is certified by AABC and/or NEBB as a TBE.

   2. Technician: Employee of the T&B agency who is certified by AABC and/or NEBB as a TBT.

B. TBE shall perform the following:

   1. Review field data reports to validate accuracy of data and to prepare certified T&B reports.

   2. Certify that the T&B team complied with the approved T&B plan and the procedures referenced in this Specification.

   3. Certify the T&B report.


D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in the AABC National Standards for Total System Balance.

1.5 CONTRACTOR RESPONSIBILITIES

A. Provide T&B agency one complete set of contract documents, change orders, and approved submittals in digital and hard copy formats

B. Controls contractor shall provide required BAS hardware, software, personnel and assistance to T&B agency as required to balance the systems. Controls contractor shall also provide trending report to demonstrate that systems are complete.

C. Coordinate meetings and assistance from suppliers and contractors as required by T&B agency.

D. Provide additional valves, dampers, sheaves and belts as required by T&B agency.

E. Flag all manual volume dampers with fluorescent or other high-visibility tape.

F. Provide access to all dampers, valves, test ports, nameplates and other appurtenances as required by T&B agency.

G. Replace or repair insulation as required by T&B agency.
H. Have the HVAC systems at complete operational readiness for T&B to begin. As a minimum verify the following:

1. Airside:
   a. All ductwork is complete with all terminals installed.
   b. All volume, smoke and fire dampers are open and functional.
   c. Clean filters are installed.
   d. All fans are operating, free of vibration, and rotating in correct direction.
   e. VFD start-up is complete and all safeties are verified.
   f. System readiness checklists are completed and returned to T&B agency.

I. Promptly correct deficiencies identified during T&B.

J. Maintain a construction schedule that allows the T&B agency to complete work prior to occupancy.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper T&B of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Note the locations of devices that are not accessible for testing and balancing.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas.

E. Examine equipment performance data including fan and pump curves.

F. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean permanent filters are installed, and controls are ready for operation.

G. Examine strainers to verify that mechanical contractor has replaced startup screens with permanent screens and that all strainers have been cleaned.

H. Examine two-way valves for proper installation and function.

I. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
K. Examine air vents to verify that mechanical contractor has removed all air from all hydronic systems.

3.2 PREPARATION

A. Prepare a T&B plan that includes:
   1. Equipment and systems to be tested.
   3. Instrumentation to be used.
   4. Sample forms with specific identification for all equipment.

B. Prepare system-readiness checklists, as described in the AABC or NEBB National Standards for Total System Balance, for use by contractors in verifying system readiness for T&B. These shall include, at a minimum:
   1. Airside:
      a. All ductwork is complete with all terminals installed.
      b. All volume, smoke and fire dampers are open and functional.
      c. Clean filters are installed.
      d. All fans are operating, free of vibration, and rotating in correct direction.
      e. VFD start-up is complete and all safeties are verified.
      f. Automatic temperature-control systems are operational.
      g. Ceilings are installed.
      h. Windows and doors are installed.
      i. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing on each system according to the procedures contained in the latest version of the AABC or NEBB National Standards for Total System Balance and in this Section.

B. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

C. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain approved submittals and any manufacturer-recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare a single-line schematic diagram of systems for the purpose of identifying HVAC components.
C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

E. Verify that motor starters are equipped with properly sized thermal protection.

F. Check condensate drains for proper connections and functioning.

G. Check for proper sealing of air-handling-unit components.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow as follows:
   a. Set outside air, return air and relief air dampers for proper position that simulates minimum outdoor air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report any artificial loading of filters at the time static pressures are measured.

3. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows.

1. Measure airflow of sub-main and branch ducts.

2. Adjust sub-main and branch duct volume dampers for specified airflow.

3. Re-measure each sub-main and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure airflow at all inlets and outlets.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after all have been adjusted.

D. Verify final system conditions.
1. Re-measure and confirm minimum outdoor air, return and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust, if necessary. Measure and record all operating data.
6. Record final fan-performance data.

3.6 TOLERANCES
A. Set HVAC system’s air flow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Minimum Outside Air: Zero to plus 10 percent.
4. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.7 FINAL TEST & BALANCE REPORT
A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the T&B process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. All measurements and test results that appear in the reports must be made on site and dated by the AABC or NEBB technicians or test and balance engineers.
B. The report must be organized by systems and shall include the following information as a minimum:
1. Title Page:
   - AABC/NEBB Certified Company Name
2. Table of Contents.

3. AABC/NEBB National Performance Guaranty.

4. Report Summary:
   - The summary shall include a list of items that do not meet design tolerances, with information that may be considered in resolving deficiencies.

5. Instrument List:
   - Type
   - Manufacturer
   - Model
   - Serial Number
   - Calibration Date

6. T&B Data:
   - Provide test data for specific systems and equipment as required by the most recent edition of the AABC or NEBB National Standards.

C. One copy of the final test and balance report shall be sent directly to the engineer of record. Provide five (5) additional copies to the contractor.

END OF SECTION 230593
PART 1 - GENERAL

1.1 RELATED DOCUMENTS:
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Specification Sections, apply to this Section.

1.2 SUMMARY:
   A. This Section includes requirements for commissioning the HVAC system and its subsystems and equipment, including the Direct Digital Control system.
   B. A registered design professional is responsible to provide evidence of mechanical systems commissioning and completion in accordance to the provisions of this section.

1.3 DEFINITIONS:
   A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of HVAC, electrical, communications, controls for HVAC systems, and other related systems.
   B. RDP: Registered Design Professional
   C. Systems, Subsystems, and Equipment: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, and equipment.
   D. TAB: Testing, Adjusting, and Balancing.

1.4 COMMISSIONING DOCUMENTATION:
   A. Commissioning Plan: A commissioning plan will be developed by a registered design professional or approved agency and shall include the following items:
      1. A narrative description of the activities that will be accomplished during each phase of commissioning, including the personnel intended to accomplish each of the activities.
      2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
      3. Functions to be tested, including, but not limited to calibrations and economizer controls.
      4. Conditions under which the test will be performed. At a minimum, testing shall affirm winter and summer design conditions and full outside air conditions.
      5. Measurable criteria for performance
B. Test Checklists: RDP, with assistance of Architect/Engineer, shall develop test checklists for each system, subsystem, or equipment including interfaces and interlocks, and include a separate entry, with space for comments, for each item to be tested. Prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. Provide space for testing personnel to sign off on each checklist.

1. Name and identification of tested item.
2. Test number.
3. Time and date of test.
4. Indication of whether the record is for a first test or retest following correction of a problem or issue.
5. Date of the test and name of parties involves as applicable.
6. Individuals present for test.
8. Note if re-test is necessary.

C. Test and Inspection Reports: RDP shall record test data, observations, and measurements on test checklists. Photographs, forms, and other means appropriate for the application shall be included with data. RDP shall compile test and inspection reports and tests and inspection certificates and include them in systems manual and commissioning report.

D. Corrective Action Documents: RDP shall document corrective action taken for systems and equipment that fail tests. Include required modifications to systems and equipment and revisions to test procedures, if any. Retest systems and equipment requiring corrective action and document retest results.

E. Issues Log: RDP shall prepare and maintain an issues log that describes design, installation, and performance issues that are at variance with the Contract Documents. Identify and track issues as they are encountered, documenting the status of unresolved and resolved issues.

1. Creating an Issues Log Entry:
   a. Identify the issue with unique numeric or alphanumeric identifier by which the issue may be tracked.
   b. Assign a descriptive title of the issue.
   c. Identify date and time of the issue.
   d. Identify test number of test being performed at the time of the observation, if applicable, for cross-reference.
   e. Identify system, subsystem, and equipment to which the issue applies.
   f. Identify location of system, subsystem, and equipment.
   g. Include information that may be helpful in diagnosing or evaluating the issue.
   h. Note recommended corrective action.
   i. Identify commissioning team member responsible for corrective action.
   j. Identify expected date of correction.
   k. Identify person documenting the issue.
2. Documenting Issue Resolution:
   a. Log date correction is completed or the issue is resolved.
   b. Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue, if any.
   c. Identify changes to the Contract Documents that may require action.
   d. State that correction was completed and system, subsystem, and equipment is ready for retest, if applicable.
   e. Identify person(s) who corrected or resolved the issue.
   f. Identify person(s) documenting the issue resolution.

3. Issues Log Report: On a periodic basis, but not less than for each commissioning team meeting, RDP shall prepare a written narrative for review of outstanding issues and a status update of the issues log. As a minimum, RDP shall include the following information in the issues log and expand it in the narrative:
   a. Issue number and title.
   b. Date of the identification of the issue.
   c. Name of the commissioning team member assigned responsibility for resolution.
   d. Expected date of correction.

F. Commissioning Report: RDP shall document results of the commissioning process including unresolved issues and performance of systems, subsystems, and equipment. The commissioning report shall indicate whether systems, subsystems, and equipment have been completed and are performing according to the Contract Documents. The commissioning report shall include, but is not limited to, the following:

1. Lists and explanations of substitutions; compromises; variances in the Contract Documents; record of conditions; and, if appropriate, recommendations for resolution. This report shall be used to evaluate systems, subsystems, and equipment and shall serve as a future reference document during Owner occupancy and operation. It shall describe components and performance that exceed requirements of the Contract Documents. It may also include a recommendation for accepting or rejecting systems, subsystems, and equipment.

2. Commissioning plan.


4. Testing plans and reports.

5. Corrective modification documentation.

6. Issues log.

7. Completed test checklists.

8. Listing of off-season tests not performed and a schedule for their completion.

G. Systems Manual: RDP shall gather required information and compile systems manual. Systems manual shall include, but is not limited to, the following:

1. Submittal Data stating equipment size and selected options for each piece of equipment requiring maintenance.
2. Operation and maintenance data on each piece of equipment requiring maintenance. Required routine maintenance actions shall be clearly identified.

3. Name and address of at least one service agency.

4. HVAC controls system maintenance and calibration information.

5. A narrative of how each system is intended to operate, including recommended setpoints.

PART 2 – PRODUCTS – Not Used

PART 3 - EXECUTION

3.1 BALANCING:

A. Scope:

1. Prior to final acceptance by the Owners, all air systems shall be balanced to deliver the quantities as specified or directed. The air balance shall be performed by an independent agency specializing in balancing and is certified by the National Environmental Balancing Bureau.

2. The Mechanical Contractor shall provide assistance to the Balancing Contractor by identifying all installed mechanical systems and assisting access to all installed mechanical systems. All mechanical systems shall be completely operational and functional prior to the Balancing Contractor performing his specified work.

B. Air balancing:

1. Balancing of the air system shall consist of:
   
   a. Adjust all air volumes to the quantities shown, with allowable variation of plus 10, minus 10 percent.
   
   b. Record all system, zone, diffuser, grille, and register C.F.M. Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels. Balancing Engineer shall work with the Contractor to set minimum & maximum CFM quantities for zone dampers, or zone dampers/heaters.
   
   c. Test and record all system static pressures, inlet and discharge, on all packaged units, fans, and terminal units. Vary total system air quantities by adjustment of fan speeds. Provide drive changes as necessary. Vary branch air quantities by damper regulation.
   
   d. Test and record motor full load amps and nameplate amps.
   
   e. Test and record entering and leaving temperatures at all coils.
   
   f. Adjust all automatically operated dampers, in cooperation with the Control Contractor,
to the required settings. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions within specified tolerances. Where modulating dampers or economizers are provided, take measurements at full return air, minimum outside air, and 100 percent outside air mode of operation.

g. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and excessive noise where possible.

h. Mark final positions of all balance dampers with a red felt pen.

i. Air systems shall be balanced in accordance with standard procedures and recognized practices of the Associated Air Balance Council, and the Testing Adjusting, and Balancing Bureau.

C. Quality Assurance:

1. The Balancing Contractor shall demonstrate to the Engineer of record, flow verification for at least 10% of the balanced devices as selected by the Engineer. If more than 25% of the tested devices do not meet the designed or balance report, then the entire system balance must be rebalanced.

D. Balance Reports:

1. Submit four copies of the air system balance report to the Architect/Engineer for evaluation and approval. Reports shall be on TABB/SMACNA forms that indicate information addressing each of the testing methods, readings, and adjustments.

3.2 TESTING:

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from RDP. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

2. Alter set points when simulating conditions is not practical and when written approval is received from RDP.

3. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

C. Scope of HVAC Subcontractor Testing.

1. Testing scope shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. It shall
include measuring capacities and effectiveness of operational and control functions.

2. Test all operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. Detailed Testing Procedures: RDP, with HVAC Subcontractor, TAB Subcontractor, and HVAC Instrumentation and Control Subcontractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. HVAC Instrumentation and Control System Testing.

1. Field testing plans and testing requirements are specified in Division 23 Sections "HVAC Instrumentation and Controls" and "Sequence of Operation." The CxA, HVAC Subcontractor, and the HVAC Instrumentation and Control Subcontractor shall collaborate to prepare testing plans.

2. CxA shall convene a meeting of appropriate entities to review test report of HVAC instrumentation and control systems.

F. Energy Supply System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of refrigerant systems and equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each equipment item and pipe section to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector showing the physical location of each designated pipe test section. Drawings shall be formatted to allow each section of piping to be physically located and identified when referred to in system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

G. Heat-Generation System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of auxiliary heating equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of heat strip to be tested, identified by identification marker. Markers shall be keyed to Drawings for each heating sector showing the physical location of each item of equipment and test section. Drawings shall be formatted to allow each item of equipment and section of heat strip to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all heating sections have been tested.

H. Refrigeration System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of all condensing units, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.
2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

I. HVAC Distribution System Testing: HVAC Subcontractor shall prepare a testing plan to verify performance of air, and refrigerant distribution systems; special exhaust; and other distribution systems. Include HVAC terminal equipment and unitary equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

J. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.

2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

END OF SECTION 230800
SECTION 230900 – BUILDING AUTOMATION SYSTEM

PART 1 - GENERAL

1.1 REFERENCES

A. American National Standards Institute (ANSI)
   1. ANSI/ISA 5.5-1985 Graphic Symbols for Process Displays.

1.2 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

A. Acronyms used in BAS.
   1. BAS – Building Automation System
   2. EMCS – Energy Management and Control System
   3. GUI – Graphical User Interface
   4. HVAC - Heating, Ventilation, Air Conditioning
   5. I/O - Input/output
   6. ISA - Industry Standard Architecture
   7. O&M - Operation and Maintenance
   8. Niagara4 – Software framework for building device-to-enterprise applications and Internet-enabled products.

1.3 STANDARDS COMPLIANCE

A. All equipment and material to be from manufacturer's regular production, UL and/or ULC or CSA certified, manufactured to standard quoted plus additional specified requirements.

B. Where UL and/or ULC or CSA certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to site.

C. Additional applicable codes and standards:
2. Local Electrical Codes
3. Federal Communications Commission -- Part J.

1.4 EXISTING CONTROL COMPONENTS

A. Re-use any existing control wiring and/or piping provided that they conform to applicable codes, standards, and specifications.

1. Sensors may be reused if the new controller supports a minimum 32 point linear interpolation translation table for the sensors.

B. Field control devices that are usable in their original configuration may be re-used provided that they conform to applicable codes, standards, and specifications. Do not modify original design of any existing devices without written permission from Owner. Provide for new, properly designed device where components are questionable as to reusability. Provide list of equipment so included in bid. Include unit price of all for this equipment.

C. Within 30 days of award of contract, and prior to installation of any new devices, inspect and test all existing devices intended for re-use. Furnish test report listing each component to be re-used and indicating whether it is in good order or requires repair by Owner.

D. Non-functioning items:

1. Provide with report specification sheets or written functional requirements to support findings.

2. Owner will repair or replace existing items judged defective yet deemed necessary for BAS.

3. Assume responsibility for items repaired by Owner.

E. Submit written request for permission to disconnect any controls and to obtain equipment downtime before proceeding with work.

F. Assume responsibility for existing controls to be incorporated into the BAS and it will commence upon approval for disconnection of controls or equipment downtime.

1. Be responsible for items repaired by Owner.

2. Be responsible for repair costs due to negligence or abuse of Owner's equipment.

3. Responsibility for existing devices to terminate upon acceptance of the entire BAS system.

G. Remove existing controls not re-used or not required. Place in Owner’s designated storage. All removed controls will remain the property of the Owner.
1.5 WORK INCLUDED

A. Provide a new building system to control and monitor the building’s mechanical and electrical systems.

B. Provide control valves, control damper actuators / end switches (gravity, fire and smoke control dampers by others), flow switches, thermal wells for temperature control, air flow stations, and other control devices as necessary.

C. Provide submittal data sheets, control drawings schematics (in Visio or AutoCAD), data entry, electrical installation, programming, start up, test and validation acceptance documentation, as-built documentation, maintenance manuals and system warranties.

D. All labor, material, equipment and services not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification shall be provided at no additional cost to the Owner.

E. The work covered by this specification and related sections consists of providing submittals, labor, materials, engineering, technical supervision, and transportation as required to furnish and install a fully operational BAS to monitor and control the facilities listed herein, and as required to provide the operation specified in strict accordance with these documents, and subject to the terms and conditions of the contract. The work in general consists of but is not limited to, the following:

1. Furnish and install all to achieve system operation, any control devices, conduit and wiring, in the facility as required to provide the operation specified.

2. Furnish complete operating and maintenance manuals and field training of operators, programmers, and maintenance personnel.

3. Perform acceptance tests and commissioning as indicated.

1.6 WORK BY OTHERS

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

B. Duct smoke detectors, smoke dampers, fire/smoke dampers, and associated actuators / end switches shall be provided under another Division of this specification. The Division 26 electrical contractor shall interlock these devices to the BAS for shutdown/monitoring unless otherwise outlined in the Sequences of Operations for this project. The BAS contractor shall coordinate where to land wires and programming as needed.

C. Switches, and power wiring to motors, starters, thermal overload switches, and contactors, is specified under another Division of this specification.

1.7 BAS OPEN SYSTEM DESIGN AND QUALIFICATIONS
A. Open System Design: It is the owners expressed goal to implement an open Building Automation System that will allow products from different manufacturers and/or suppliers to be integrated into a single unified system in order to provide flexibility for expansion, maintenance, and service of the system. The BAS manufacturer / contractor must provide proof of open system design as outlined below.

B. Prior to award of the contract the BAS contractor is to provide proof of “Open System Design” with the following requirements:

1. Provide proof of having a local office within 50 miles [80 km] of project for at least 5 years, staffed by trained personnel capable of providing installation, engineering, programming, servicing, commissioning, instruction, routine maintenance, and emergency service on systems.

2. The controls system shall utilize the Niagara4 software framework.
   a. The Contractor shall have a minimum of 2 years’ experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.
   b. Submit the Niagara Compatibility Statement (NiCS) via a letter from the manufacturer. The NiCS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of “All”).

3. The controls system shall conform to the following guidelines for communication protocols.
   a. BACnet shall be used for all BAS provided controllers.
      1) The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (https://www.bacnetinternational.net/btl/search.php)

      2) The use of BACnet Communications protocol alone shall NOT warrant an “Open System Design.” Manufacturers must adhere to all aspects of “BAS Open System Design and Qualifications” and “Acceptable System Manufacturers” sections to comply.
   b. Modbus shall only be acceptable for third party devices.
   c. LonTalk shall only be acceptable for sites with existing LonTalk controls architecture where the owner has explicitly stated that the LonTalk architecture must remain in place.
   d. Proprietary communications protocols shall NOT be acceptable.

4. A software programming tool shall be provided for this project and adhere to the following guidelines:
   a. All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or his designated agent.
   b. The software programming tool shall be free of charge and openly available for download from the internet.
c. For any manufacturer that does not have a free programming tool the manufacturer must provide the tool with this project for a minimum of 5 years with proof of availability via letter from the manufacturer.
d. Any licensing required by the manufacturer now and to the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, to allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SYSTEM MANUFACTURERS AND CONTRACTORS

A. Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems for a minimum of 5 years.

B. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll free number that is staffed with qualified personnel, capable of providing instruction and technical support service for networked control systems.

C. BACnet/IP communication protocol must be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

D. Any approved manufacturer that can supply both equipment and controls must provide controls pricing separately from equipment pricing.

E. Acceptable Manufacturers

1. Distech Controls (Basis of Design)
   a. Installed by Sunbelt Controls
      1) Casey Crown / Brett Scarrow
      2) ccrown@sunbeltcontrols.com / bscarrow@sunbeltcontrols.com
      3) 208.888.7168

2.2 QUALITY ASSURANCE

A. All new building automation system products on this project shall be provided by a firm that is a registered ISO 9001:201508 manufacturer, for a minimum duration of 5 years, at time of bid.

2.3 COMPUTER HARDWARE

A. Provide the following computer hardware for this project:

1. Uninterruptable Power Supplies

B. Uninterruptable Power Supplies
1. Provide the OWS, Server, and each network/building controller with individual UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

2. Acceptable Manufacturer is APC.

2.4 REMOTE ACCESS AND CYBER SECURITY BEST PRACTICES

A. Remote Access

1. The BAS contractor shall comply with owner IT infrastructure security policies for remote access. The owner IT team shall provide VPN, firewalls, etc. as needed for secure remote access.

2. A VPN and firewall must be used for secure remote access.

B. Cyber Security Best Practices

1. Unless predetermined by the owner IT team the BAS network shall be separate from the owners IT infrastructure besides a single point connection for remote access (owner provided internet access). All ethernet switches and communication backbone required for a fully operational BAS shall be provided by the BAS contractor.

2. Refer to “Communication Backbone” section of this specification for further details on segmenting the network (VLANs, subnets) and when edge or managed switches are required based on building size / type.

3. Do not use factory provided usernames and passwords. Update passwords and usernames regularly for strong system security.

4. Update software and firmware regularly.

5. Adhere to controls manufacturer hardening guidelines where applicable.

2.5 OPERATOR SOFTWARE

A. Real-Time Displays

1. Provide a visual graphical representation of buildings, floor layouts, each piece of mechanical equipment and/or mechanical system that duplicates the represented system, presented as a web page via any industry standard web browser, where applicable.

2. Graphics shall include at a minimum the value of each input, each output, each setpoint, alarms and graphical representation of trend logs.

B. On-Line Help

1. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
C. Security
   1. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.
   2. System security shall be selectable for each operator.
   3. The system administrator shall have the ability to set passwords and security levels for all other operators.
   4. Each operator password shall be able to restrict the operators’ access for viewing and/or changing each system application, full screen editor, and object.
   5. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
   6. This auto log-off time shall be set per operator password.
   7. All system security data shall be stored in an encrypted format.

D. System Diagnostics.
   1. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.
   2. The failure of any device shall be annunciate to the operator.

E. Third-Party Windows-Based Programs
   1. The system shall be capable of utilizing third-party Windows-based programs for such things as spreadsheet analysis, graphing, charting, custom report generation, and graphics design packages.
   2. Graphics generation shall be done using standard Windows packages.
   3. No proprietary graphics generation software shall be needed.

F. Overrides
   1. It shall be possible for the operator to override automatic analog and digital output commands.
   2. Where the BAS software normally originates these outputs, the provision shall exist for the operator to terminate automatic BAS control of any particular output and to originate a manual analog or digital output command.
   3. The provision shall exist for the operator to return analog or digital output command functions to automatic BAS software control.

G. Password Protection
   1. Provide security system that prevents unauthorized use unless operator is logged on.
H. Trend Data

1. System shall periodically gather historically recorded selected samples of object data stored in the field equipment (global controllers, field controllers) and archive the information on the operator’s workstation (server) hard disk.
   a. Archived files shall be appended with new sample data, allowing samples to be accumulated over 3 years.
   b. Systems that write over archived data shall not be allowed, unless limited file size is specified.
   c. Samples may be viewed at the operator’s terminal in a trend log.
   d. Logged data shall be stored in spreadsheet format.
   e. Operator shall be able to scroll through all trend log data.

2. Software shall be included that is capable of graphing the trend logged object data. Software shall be capable of creating two-axis (x,y) graphs that display up to six object types at the same time in different colours and these Graphs shall show object type value relative to time.

3. Operator shall be able to change trend log setup information such as time intervals and objects logged

I. Graphics

1. The operator’s workstation shall display all data associated with the project.
   a. Operator’s workstation shall display all data using 3-D graphic representations of all mechanical equipment.

2. System shall be capable of displaying graphic file, text, and dynamic object data together on each display.
   a. Information shall be labelled with descriptors and shall be shown with the appropriate engineering units.
   b. All information on any display shall be dynamically updated without any action by the user.
   c. Terminal shall allow user to change all field-resident BAS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen no matter if that screen shows all text or a complete graphic display.

3. Animated graphic objects shall be displayed as a sequence of multiple bitmaps to simulate motion.

4. Analog objects may also be assigned to an area of a system graphic, where the colour of the defined area would change based on the analog objects value.
   a. For example, an area of a floor-plan graphic served by a single control zone would change colour with respect to the temperature of the zone or its deviation from setpoint.

5. Separate Displays shall be supplied, specific to the project, to form the following overall presentation style.
6. All Displays will be linked in a logical fashion using hyperlink style (single left mouse click on text/display object/dynamic to load linked display if programmed)

7. Entire system shall operate without dependency on the operator's terminal. Provide graphic generation software at each workstation.

J. Alarms

1. Operator’s terminal shall provide audible, visual, electronic and printed means of alarm indication.

2. Any alarm may be handled based on its individual or assigned class actions.
   a. Displayed on the Alarm console.
      1) The system shall be provided with a dedicated alarm window or console.
      2) This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm.
   b. Alarm reports shall be viewable via the BAS system and available for delivery by electronic mail (e-mail) or printing.

3. System shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the system operator’s terminal.
   a. Each entry shall include a description of the event-initiating object generating the alarm, time and date of alarm occurrence, time and date of object state return to normal, and time and date of alarm acknowledgement.

K. Scheduling

1. Operator’s terminal display of weekly schedules shall show all information in easy-to-read 7-day (weekly) format for each schedule.

2. Exception schedules (non-normal schedules, such as holidays or special events) shall display all dates that are an exception to the weekly schedules.

3. At the operator’s terminal, the system user shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.

L. Archiving

1. Store back-up copies of all controller databases in at least one OWS and the server.

2. Provide continuous supervision of integrity of all controller databases.

3. Data base back up and downloading to occur over LAN without operator intervention.

4. Operator to be able to manually download entire controller database or parts thereof.

M. Reports

1. Provide a report facility to generate and format for display, printing, or permanent storage, as selected by the operator, the reports as specified in this section.
2. Provide the software to automatically generate any report specified; the user will be able to specify the type of report, start time and date, interval between reports (hourly, daily, weekly, monthly) and output device.

3. As a minimum, the following reports shall be configured on the system:
   a. Dynamic Reports: To allow operator to request a display of the dynamic value for the user specified points which shall indicate the status at the time the request was entered and updated at an operator modifiable scan frequency.
   b. Summary Report: To permit the display or printing of the dynamic values for the user specified points.
   c. Trend Reports: To permit the trending of points selected by the operator, including as a minimum digital input and output, analog input and output, set points, and calculated values.
   d. Historical Data Collection: Provision shall be made to ensure historical data is not lost.
   e. Alarm Summary: Provide a summary of all points in alarm and include as a minimum; point acronym, point description, current value, alarm type, limit exceeded, and time and date of occurrence.
   f. Disable Point Summary: Provide a summary of all points in the disabled state and include as a minimum point acronym and point description.
   g. Run Time Summary: Provide a summary of the accumulated running time of selected pieces of equipment with point acronym and description, run time to date, alarm limit setting. The run time shall continue to accumulate until reset individually by means of suitable operator selection.
   h. Schedule Summary: Provide a summary of all schedules and indicate as a minimum, which days are holidays and, for each section, the day of the week, the schedule times and associated values; for digital schedules value will be on or off; for analog schedules value will be an analog value.
   i. User Record Summary: Provide a summary of all user records to include as a minimum; user name, password, initials, command access level and point groups assigned.

2.6 BAS CONTROLLERS

A. All controllers on the job shall have the following minimum requirements:

1. IP Communication (BACnet/IP)
   a. BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)
   b. Support for IPv4 addressing
   c. DHCP support and Auto DNS
   d. Baud rate of not less than 100 Mbps
   e. 2 - RJ45 ports each capable of supporting 10/100 Base-T.
      1) Supporting controller daisy chaining on the Ethernet network via integral switch functionality.
      2) Integrated fail-safe should allow for communication when the controller is powered down.
   f. All controllers shall be able to communicate peer-to-peer without the need for a Network Control Unit (such as JACE, NAE, etc.) and shall be capable of assuming all responsibilities typically assumed by a Network Control Unit.
1) Any controller on the Ethernet Data Link/Physical layer shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other controller connected on the same communication cabling. Slave controllers are not acceptable.

2) The resulting network will be a ‘Flat’ topology with all devices (controllers, workstations, …) connecting at the same physical network level

2. Memory and Processing
   a. 512KB of RAM and 4GB of non-volatile flash memory.
   b. 32-bit microprocessor operating at a minimum of 600 MHz

3. Each individual controller shall have an embedded web-based HTML5 visual interface with the following functionality without reliance on any other controller for access:
   a. Typical and custom control processes
   b. Scheduling
   c. Energy management applications
   d. Alarm management applications
   e. Historical/trend data for points specified
   f. Maintenance support applications
   g. Graphical interface

4. Shall be capable of monitoring/controlling the following types of inputs/outputs:
   a. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
   b. Analog inputs of 4-20 mA, 0-10 Vdc, thermistor and RTD in the range 0 to 350,000 ohm.
   c. Digital outputs including Form C relay outputs and Triac outputs
   d. Analog outputs of 4-20 mA and 0-10 Vdc.
   e. A minimum of 10% spare capacity for each point type for future point connection.

5. Any software required for programming shall be unlicensed and openly available

6. Auto commissioning features shall be available for VAVs and FCUs to schedule automatic testing and record values (air flows, pressures, temperatures, etc.) for different operating modes. The auto commissioning feature shall be able to email reports and run commissioning on a specified schedule.

7. Power and Environmental Requirements:
   a. 24 VAC with local transformer power
   b. The controllers shall also function normally under ambient conditions of -32 °F [0 °C] to 122 °F [50 °C] and 0% to 90% RH (non-condensing).
   c. Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

8. Code Compliance:
   a. “FIPS 140-2 Level 1 Compliant” cryptographic module
   b. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.
   c. UL916 Energy management equipment
   d. FCC rules part 15, subpart B, class B
   e. UL94-V0 flammability rating
2.7 CONTROL PANELS
A. Indoor control cabinets located in offices or dry/dust free environments shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
B. All outdoor control cabinets and control cabinets located in mechanical/electrical rooms shall be NEMA 4.
C. Control panels containing more than 4 controllers shall be provided with a terminal strip for field wiring. All control wiring inside the panel shall be between a terminal strip and controller inputs/outputs. All field control wiring shall be terminated at the terminal strip. Field control wiring inputs/outputs shall never be run directly to inputs/outputs of controller.

2.8 AUTOMATIC CONTROL DAMPERS
A. Provision of dampers shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing actuators/end switches for control dampers).

2.9 VARIABLE FREQUENCY DRIVES (VFDS)
A. Provision of variable frequency drives shall be provided by another section of this specification (the BAS contractor shall only be responsible for providing associated low voltage wiring and controls programming for the VFDs).

2.10 AUXILIARY CONTROL DEVICES, SENSORS, AND TRANSMITTERS
A. Control Valves
  1. Hydronic System Two and Three-way Control Valves:
     a. Ball Valve (only acceptable for valves 2” [50 mm] and smaller): Nickel-plated forged brass body rated at no less than 400 psi [2760 kPa], stainless steel ball and blowout proof stem, NPT female end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a Tefzel flow characterizing disc.
     b. Globe Valve (valves 2” [50 mm] and smaller): ANSI Class 250 bronze body, stainless steel stem, brass plug, bronze seat, and a TFE packing.
     c. Globe Valve (valves 2.5” [62.5 mm] to 5” [125 mm]): ANSI Class 125 cast iron body, stainless steel stem, bronze plug, bronze seat, and a TFE V-ring packing. End connections shall be flanged.
     d. Sizing
        1) Two-Position: Line size or size using a pressure differential of 1 psi.
        2) 2-way Modulating: 5 psig [35 kPa] or twice the load pressure drop, whichever is greater.
        3) 3-way Modulating: Twice the load pressure drop, but not more than 5 psig [35 kPa].
     e. Flow Characteristics: 2-way valves shall have equal percentage characteristics; 3-way valves shall have linear characteristics.
f. Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 150% of the design pressure differential across the 3-way valves.
g. Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

2. Steam Control Valves:
a. Globe Valve (valves 2" [50 mm] and smaller): ANSI Class 250 bronze body; stainless steel seat, stem and plug; and a TFE packing.
b. Globe Valve (valves 2.5" [62.5 mm] to 6" [150 mm]): ANSI Class 125 [250] cast iron body; stainless steel seat, stem and plug; and a TFE V-ring packing.
c. Sizing:
   1) Two-Position: Line size or sized using 10% of inlet gauge pressure.
   2) Modulating: 15 psig [105 kPa] or less inlet steam pressure, the pressure drop shall be 80% of inlet gauge pressure. Higher than 15 psig [105 kPa] inlet steam pressure the pressure drop shall be 42% of the inlet absolute pressure.
d. Flow Characteristics: Linear or equal percentage characteristics.
e. Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of operating (inlet) pressure.
f. Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

3. Butterfly Control Valves:
a. Butterfly Valve (valves 6" [150 mm] to 12" [300 mm]): Valve body shall be full lugged cast iron 200 psig [1380 kPa] body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. External mechanical methods to achieve this mechanical connection, such as pins or screws, are not acceptable. The shaft shall be supported at four locations by RPTFE bushings. Close-off pressure rating of 200 psi [1380 kPa] bubble tight shut-off.
b. Butterfly Valve (valves 14" [350 mm] and larger): Valve body shall be full lugged cast iron 150 psig [1035 kPa] body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings. Close-off pressure rating of 150 psi [1035 kPa] bubble tight shut-off.
c. Sizing:
   1) Two-Position: Line size or size using a pressure differential of 1 psi.
   2) Modulating: [5 psig [35 kPa]] or twice the load pressure drop, whichever is greater. Size for the design flow with the disc in a 60° open-position with the design velocity less than 12 feet [3.7 m] per second.
d. Power Requirements: 24 VAC, 24 VDC, or 120VAC as required by manufacturer

4. Zone Control Valves (On/Off, Two-Position Applications):
a. Zone Valve (valves 1" [25 mm] and smaller): Forged brass body, rated at no less than 300 psi, [2070 kPa] female NPT union or sweat with a stainless steel stem and EPDM seals.
b. Sizing:
   1) Two-Position: Line size or size using a pressure differential of 1 psi, [7 kPa]
c. Close-off Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150% of total system head pressure for 2-way valves and 125% of the design pressure differential across the 3-way valves.
d. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory.
e. Power Requirements: 24 VAC or 24VDC

5. Acceptable Manufacturers:
   a. Belimo
   b. Distech Controls
   c. Bray

B. Damper Actuators

1. Features:
   a. Electronic Damper Actuators: Actuators shall be sized for torque required for sealing the damper at load conditions, shall utilize v-bolt dual nut clamp with v-shaped toothed cradle coupling, and shall be capable of being mechanically or electrically paralleled to increase torque if required. Electronic overload protection or digital rotation-sensing circuitry shall be used to prevent any damage to the actuator during a stall condition (and shall not require the use of end switches for protection). Fail-safe operation shall be provided as mechanical spring return (or electrical if spring return is not available for actuator size).
   b. Terminal Unit Actuators: Actuators shall be sized for torque required for sealing the damper at load conditions and shall utilize V-bolt dual nut clamp with a V-shaped toothed cradle or an ISO-style direct-coupled mounting pad coupling. Close of differential pressure rating of 200psi.

2. Operating Temperature: -22° F to 122° F (-30° C to 50° C)

3. Protection / Rating: Minimum requirement NEMA type 2 / IP54 mounted in any orientation, NEMA 4X for outdoor applications, and UL94-5V(B) flammability for terminal unit actuators

4. Input/Output:
   a. Two Position: Digital output including Form C relay output
   b. Modulating: 4-20 mA and 0-10 Vdc.
   c. End Switches / Auxiliary Switches (if applicable): SPDT, digital inputs from dry contact closure

5. Power:
   a. Electronic Damper Actuators: Two position spring return shall be 24 or 120VAC as required by manufacturer and proportional actuators shall be 10VA at 24VAC or 8W at 24VDC
   b. Terminal Unit Actuators: maximum of 1 VA at 24VAC or 1 W at 24VDC

6. Agency Approvals:
   a. Electronic Damper Actuators: ISO 9001, UL, UL(C) and CSA C22.2 No. 24-93.
   b. Terminal Unit Actuators: CE, UL 60730-1A/-2-14, CAN/CSA E60730-1, CSA C22.2 No. 24-93, CE according to 89/336/EEC.

7. Approved Manufacturers / Models:
   a. Distech Controls
   b. Belimo
C. Air Flow Measuring Station

1. Features:
   a. Duct Air Flow Measuring Station: Highly accurate thermal dispersion airflow and temperature measuring probe(s) designed for duct sizes 8 – 120”. Multiple velocity and temperature points on one or more probes installed in the duct or plenum are averaged to arrive at air measurements. Capable of displaying the flow and temperature at each sensing point. Moisture resistant flex sensors protected from the elements with a thin conformal coating. Includes airfoil-Shaped aluminum probes with LCD screen digital display controller and the correct number of ancillary probes based on the size of the duct.
   b. Fan Inlet Air Flow Measuring Station: Shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location scheduled through two or four sensing circuits and a control transmitter that communicates with the building automation system (BAS). Includes aerodynamically shaped, surface mount fan inlet sensors and LCD screen control transmitter.

2. Operating Temperature: -20° F to 120° F (-29° C to 49° C)

3. Protection / Rating: U.L. 94 flame rated, high impact ABS

4. Input/Output:
   a. Velocity Output: 4-20mA or 2-10 VDC with 500 ohm resistor
   b. Temperature Output: 4-20mA or 2-10 VDC with 500 ohm resistor
   c. BACnet MS/TP (for duct air flow measurement stations)

5. Power: 24 VAC (+/- 15%); 15 VA

6. Accuracy: ±3% of reading with ±0.25% repeatability and ±0.10° F (0.06˚ C)

7. Range: 0-5000 FPM for ducts and 0-10,000 FPM for fan-inlet

8. Agency Approvals: All components are U.L. Listed and compliant with RoHS directive 2002/95/EC, AMCA, and ISO 9001. In addition duct airflow measuring stations are compliant with Part 15 of the FCC rules and BTL.

9. Approved Manufacturer / Model:
   a. Duct Air Flow Measuring Station: Ruskin (TDP05K)
   b. Fan Inlet Air Flow Measuring Station: Ruskin (EFAMS)
   c. Other Approved Manufacturers: Ebtron

D. Water Pressure Sensor

1. Features: Provide water pressure sensors as indicated within the sequences of operations and/or controls diagrams with operating range suitable for application. Select range such that it covers from zero pressure to twice the amount of pressure desired for control purposes or that could be encountered. Sensor shall include over pressure input protection of a minimum two times rated input, burst pressure of a minimum five times rated input, and 17-4PH stainless steel wetted parts

2. Operating Temperature: -40° F to 185° F (-40° C to 85° C)
3. Protection / Rating: 17-4 PH Stainless Steel or NEMA 4X if enclosure provided
4. Input/Output: 4-20 mA output proportional to water pressure
5. Power: 3-wire circuit for power and output (COM, OUT, EXC) with EXC being 15-30 VDC (18-30 VAC)
6. Accuracy: ± 1% of full scale
7. Range: selectable pressure range 1 – 10,000 psi
8. Agency Approvals: CE & RoHS Compliant
9. Approved Manufacturer / Model:
   a. Setra (Model 2091)
   b. Distech Controls (PS-2LSP Series)

E. Water Differential Pressure Sensor

1. Features: Provide water differential or gage pressure sensors as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range such that it covers from zero differential pressure up to a differential static pressure of 20% to 50% in excess of the maximum static pressure that could be encountered. Remember that if the sensor is used for the control of a chilled water bypass and is located across, for example, a chilled water AHU coil, the pressure drop of both the coil and the associated valve at full design flow have to be taken into account. Sensor shall include over pressure input protection of a minimum two times rated input, burst pressure of a minimum five times rated input, and 17-4PH stainless steel wetted parts.

2. Operating Temperature: -4° F to 185° F (-20° C to 85° C)
3. Protection / Rating: NEMA 4 or NEMA4X if enclosure provided
4. Input/Output: 4-20 mA output proportional to pressure sensed
5. Power: 3-wire circuit for power and output (COM, OUT, EXC) with EXC being 15-30 VDC (18-30 VAC)
6. Accuracy: ± 1% of full scale
7. Range: selectable pressure range 1 – 500 psi
8. Agency Approvals: CE & RoHS Compliant
9. Approved Manufacturer / Model:
   a. Setra (Model 231)
   b. Distech Controls (PS-2LDP Series)

F. Air Pressure Sensor – Duct / Space / Air Differential (Filter/Coil Monitoring)
1. Features: Provide air pressure sensors as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range as detailed below based on application type. Sensor shall include over pressure input protection of a minimum two times rated input or 20 psi (whichever is greater).
   a. Duct Mounted Static Pressure Sensor: Select range such that it covers from zero duct static pressure relative to the exterior of the duct up to a static pressure of between 20% and 50% in excess of the maximum static pressure that could be encountered in the duct relative to the duct exterior. Typically, for low pressure commercial duct consider using a range of 0 to 2” wc (0 to 500Pa), for medium pressure duct use a range of 0 to 6” wc (0 to 1500Pa) and for high-pressure duct use a range of 0 to 10” wc (0 to 2500 Pa).
   b. Space Static Pressure Sensor: Input range of -0.2” to + 0.2” wc (–50 to +50 Pa).
   c. Air Differential Pressure Sensor: Select range as required, taking into consideration pressure drop across filter or coil. Typically 0-2” wc (0 to 500 Pa) range for low-pressure commercial duct.

2. Operating Temperature: 32° F to 140° F (0° C to 60° C)

3. Protection / Rating: Polycarbonate (UL 94 V-0 Approved)

4. Input/Output: 4-20 mA, 0-5V, or 0-10V output proportional to pressure sensed

5. Power: 24VAC or 24VDC

6. Accuracy: ± 1% of full scale

7. Range: selectable pressure range 0- 20” w.c.

8. Agency Approvals: UL listed

9. Approved Manufacturer / Model:
   a. Setra
   b. Distech Controls

G. Air Pressure Switch

1. Features: Provide air pressure switches as indicated within the sequences of operations and/or controls diagrams suitable for application. Select range as required, taking into consideration pressure drop across filter or coil. Typically 0.2-2” wc (0 to 500pa) range for low-pressure commercial duct. Sensor shall include over pressure input protection of a minimum two times rated input or 20 psi (whichever is greater).

2. Operating Temperature: -4° F to 140° F (-20° C to 60° C)

3. Protection / Rating: IP54 (NEMA 13) polycarbonate

4. Input/Output: SPDT switch digital input from dry contact closure

5. Power: N/A

6. Accuracy: ± 1% of full scale
7. Range: selectable pressure range 0- 12” w.c.

8. Agency Approvals: N/A

9. Approved Manufacturer / Model:
   a. Setra
   b. Distech Controls

H. Gas Sensor and Control System

1. Features: Self-contained dual gas sensor that is network ready for either peer-to-peer (master slave) operation or central control for a smooth integration into new or existing energy management system. Impact resistant water proof enclosure, 3 adjustable alarm relays, indicators and strobe (Red LED alarm indicators, level 1 and 2 High intensity white LED strobe and audible alarm on level 3). The sensor shall include an 85db audible alarm and LCD display for calibration, user settings, and displaying gas concentrations. Sensor shall be placed in locations outlined within sequences of operations, mechanical plans, and/or control diagrams. Mounting heights and distance covered shall also adhere to manufacturer recommendations. Sensor shall be factory calibrated and will only require calibration after a minimum one (1) year service.

2. Operating Temperature: -4° F to 104° F (-20° C to 40° C)

3. Protection / Rating: ABS UL-94-V0, UL-94 - 5VA, Nema 4

4. Input/Output:
   a. 4-20 Ma or 2-10V analog output
   b. 2 Relays SPDT, 5 amp @ 125 vac, non-inductive
   c. RS-485 serial interface BACnet MS/TP

5. Power: 24 V AC

6. Accuracy: ± 2% of full scale

7. Range: ppm or %LEL based on manufacturers recommendations

8. Agency Approvals: UL61010-1, CSA C22.2 61010-1-12, ANSI/ISA 61010-1, CSA C22.2 no. 205-12

9. Approved Manufacturer / Model:
   a. Opera (Model 6000)
   b. Approved Equal

I. Air Quality Sensor

1. Features: Air quality sensor that is able to detect poor air quality from a broad range of volatile organic compounds (VOCs) such as cooking odors, smoke, bioeffluence, outdoor pollutants and from human activities. The air quality sensor shall detect volatile organic compounds beyond typical CO2 applications. Sensor shall be space mounted or duct mounted in locations outlined within sequences of operations, mechanical plans, and/or control diagrams.
2. Operating Temperature: 32° F to 122° F (0° C to 50° C)

3. Protection / Rating: Polycarbonate, UL94-V0, IP65 (NEMA 4X)

4. Input/Output:
   a. 0-5V or 0-10V analog output

5. Power: 24 V AC

6. Accuracy: ± 2% of full scale

7. Range: 450-2000ppm CO2 equivalent

8. Agency Approvals: UL94-V0

9. Approved Manufacturer / Model:
   a. Distech Controls (GS-2AQD) [duct mounted]
   b. Distech Controls (GS-AQR) [wall mounted]
   c. Approved Equal

J. Carbon Dioxide (CO2) Sensor

1. Features: Provide a space or duct carbon dioxide gas detection sensor as indicated within the sequences of operations and/or control diagrams. Optional features include BACnet communication, LCD display, setpoint adjustment, or integral temperature/humidity sensors (optional features shall be provided if necessary based on project scope).

2. Operating Temperature: 32° F to 122° F (0° C to 50° C)

3. Input/Output: 4-20 mA, 0-10 or 0-5 Vdc output compatible with BMS proportional to carbon dioxide concentration

4. Power: 24VAC or 24VDC

5. Accuracy: ± 3% of full scale

6. Range: 0 to 2000 ppm

K. Duct / Immersion / Outdoor Temperature Sensors

1. Features: Provide Thermistor or RTD temperature sensors as indicated within the sequences of operations and/or control diagrams. Install sensor as detailed below.
   a. Outside Air Temperature Sensor: Provide outside air temperature sensors with Aluminum LB with PVC sun and windscreen weatherproof enclosure with conduit entrance. Install in an area where exhaust or roof heat will not affect readings.
   b. Duct Mounted Temperature Sensor (ducts less than 10ft² [1m²] in cross-sectional area): Provide duct mounted, single point temperature sensor with 0.25” [6.35 mm] stainless steel probe of length between one-third and two-thirds of the duct width.
c. Duct Mounted Averaging Temperature Sensor (ducts greater than 10ft² [1m²] in cross-sectional area): Provide duct mounted, averaging, temperature sensor with probe length of 12 feet [3.66m] minimum or 1 ft per ft² (3.25m per m²) of duct cross-sectional area, whichever is greater. Copper sheathed or plenum rated flexible construction.
d. Liquid Temperature Sensor: Provide immersion thermowell mounted temperature sensors for liquid temperature sensing. Rigid 0.25” [6.35mm] stainless steel probe of length, which is, at minimum, 20% of the pipe width. Provide Brass or Stainless steel thermowell (316 or 304) with thermal grease to aid temperature sensing.
e. Strap-on Temperature Sensor: Provide strap-on mounted temperature sensors where thermo well mounted sensors cannot be mounted.

2. Operating Temperature: -58° F to 212° F (-50° C to 100° C) dependent upon application
3. Input/Output: thermistor or RTD compatible with BAS
4. Power: dependent upon sensor type – provide as per manufacturers recommendations
5. Accuracy: ± 1.0°F (0.5 °C)
6. Range: -58° F to 212° F (-50° C to 100° C) dependent upon application

L. Duct / Outdoor Humidity Sensors
1. Features: Provide duct / outdoor humidity sensors as indicated within the sequences of operations and/or control diagrams. Outside air humidity sensors shall have ABS hinged weatherproof housing with conduit entrance and shall be installed in an area where exhaust or roof heat will not affect readings. Duct humidity sensors shall have ABS housing with conduit entrance. In addition all humidity sensors shall have 9” probe length, 60 micron HDPE filter, reverse voltage protection, and be output limited.

2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
3. Input/Output: 4-20 mA two wires, 0-10 Vdc and/or 0-5 Vdc output proportional to relative humidity range of 0% to 100%
4. Power: 24VAC or 24VDC
5. Accuracy: ± 3% of full scale
6. Range: 5-95%RH

M. Space Temperature Sensors
1. Features: Provide space temperature sensors as indicated within the sequences of operations and/or control diagrams. Shall consist of an element within a ventilated cover. Space sensors located in mechanical rooms and large public spaces shall contain a network jack, but shall have no ability to adjust temperature setpoint (Set Point Adjustment). Space sensors located in other spaces shall include options (setpoint adjustment, network jack, fan speed selection, override switch, and/or digital display) in accordance with the drawings and sequences of operations.
2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
3. Input/Output: dependent upon sensor type – provide as per manufacturers recommendations
4. Power: dependent upon sensor type – provide as per manufacturers recommendations
5. Accuracy: ± 1.0°F (0.5 °C)
6. Range: 32° F to 122° F (0° C to 50° C)

N. Space Humidity Sensors

1. Features: Provide space humidity sensors as indicated within the sequences of operations and/or control diagrams. Sensor shall have reverse voltage protection and be output limited.
2. Operating Temperature: 32° F to 122° F (0° C to 50° C)
3. Input/Output: dependent upon sensor type – provide as per manufacturers recommendations
4. Power: dependent upon sensor type – provide as per manufacturers recommendations
5. Accuracy: ± 3% of full scale
6. Range: 5-95%RH

O. Combination Relative Humidity And Temperature Sensors

1. Where there is a requirement for the monitoring of both relative humidity and temperature at the same location, the BMS Contractor shall provide a combination relative humidity sensor and temperature sensor. The individual sensors must each meet the specifications details above.

P. Low Limit Thermostats

1. Features: Provide low limit thermostats as indicated within the sequences of operations and/or control diagrams. Safety low limit thermostats shall be vapor pressure type with an element 20 ft [6.1 m] minimum length. Element shall respond to the lowest temperature sensed by any one foot section. Low limit shall be manual reset only.
2. Operating Temperature: -60° F to 160° F (-51° C to 71° C)
3. Input/Output: 2 SPDT switches, digital inputs from dry contact closure
4. Power: N/A
5. Accuracy: ± 1.0°F (0.5 °C)
6. Range: adjustable range 34° F to 70° F (1° C to 21° C)
Q. Current Relay/Switch

1. Features: Provide current sensing relays as indicated within the sequences of operations and/or control diagrams. The current sensing relay shall be rated for the applicable load, shall have input and output isolation via current transformer, and the output relay shall have an accessible trip adjustment over its complete operating range. Whenever the status of a single speed motor is monitored it shall be done via a current sensing relay. The BAS contractor shall provide current sensing relays at the MCC starters (or at the local starter for motors without a MCC starter).

2. Operating Temperature: 5° F to 140° F (-15° C to 60° C)

3. Input/Output: digital input from dry contact closure

4. Power: Current relay shall be self-powered with no insertion loss

5. Accuracy: ± 2% of full scale

R. Current Sensor

1. Features: Provide current sensors as indicated within the sequences of operations and/or control diagrams. The current sensors shall be rated for the applicable load and shall be reverse polarity protected and output limited.

2. Operating Temperature: -20° F to 120° F (-29° C to 49° C)

3. Input/Output: 4-20 mA, 0-10 or 0-5 Vdc output proportional to current draw

4. Power: Current sensor shall be self-powered with no insertion loss

5. Accuracy: ± 1% of full scale

S. Leak Detection Monitoring – Water

1. Features: Provide leak detectors as indicated within the sequences of operations and/or control diagrams. The appropriate leak detector type should be provided based on application (i.e., spot leak detector for drain pans and rope leak detector for floors). Leak detectors shall be corrosion and abrasion resistant.

2. Operating Temperature: 50° F to 104° F (10° C to 40° C)

3. Input/Output: (2) Form C relays, digital input from dry contact closure

4. Power: 24 VAC

T. Damper End Switch

1. Features: Provide damper end switches as indicated within the sequences of operations and/or control diagrams. End switches shall prove a damper has reached the position specified. End switches shall be integral to damper actuator unless otherwise specified.

2. Input/Output: SPDT switch, digital input from dry contact closure
2.11 OCCUPANT CENTRIC BLUETOOTH LOW ENERGY (BLE) SENSORS [COMPATIBLE WITH MOBILE OCCUPANT APPLICATION]

A. Mobile Occupant Application

1. Features:
   a. The application can be installed on any smartphone running minimum Android OS 5+ (Lollypop) or Apple iOS 10+
   b. The application provides occupant access to manage temperature, fan, speed, lighting, and shades/sunblinds (dependent upon systems integrated to the BAS).
   c. Connection of the application to the room control interface is via low energy Bluetooth utilizing Bluetooth access points at BLE-Enabled Multi-Sensor and BLE-Enabled Intelligent Room Interface (Allure UNITOUCH) locations
   d. The occupant interface shall, at a minimum, have the following functions:
      1) Overrides. The occupant interface shall provide an override menu to view a limited list of the controller’s overridden points such as value, constant, or variable. The menu shall allow the operator to select an overridden point/value and to modify or release the override on the selected point/value.
      2) The Personal Comfort option allows a user to save, edit or remove a group of pre-set room preferences for quick and easy access at any time
      3) The occupant can define their personal preferences (units, theme, favorite devices, etc.) to customize their user interface and space comfort settings
      4) Favorite devices can also be defined in order to automatically connect to the most frequently used device
   e. All control screens have been designed with the occupant in mind, making this app easy to use, regardless of one’s technical skillset

2. Approved Manufacturers:

   a. Distech Controls

B. BLE-Enabled Multi-Sensor

1. Features: The BLE-Enabled Multi-Sensor (BEMS) shall communicate with any Distech Controls ECLYPSE controller and shall provide precise environmental zone values for luminosity, motion sensing, and temperature as well as Bluetooth low energy connectivity. In addition the BEMS also integrates beacon technology that can be used in solutions such as indoor positioning systems (IPS). The BEMS shall be capable of being daisy chained (using a subnet adapter) on controller communicating subnet via RS-485 connection and shall be locally able to pair with mobile occupant application via Bluetooth low energy connectivity. The sensor shall be designed for in-ceiling mounting.

2. Operating Temperature: 41° F to 104° F (5° C to 40° C)

3. Protection / Rating: ABS plastic housing, UL94V-1

4. Input/Output:
   a. Wired Connection – RS-485, Type T568B Cat 5e network cable (4 twisted pairs), maximum length 328 ft (100m)
   b. Wireless Communication – Bluetooth v4.2 (Frequency: 2402 – 2480 MHz)
5. Power: from controller via RS-485 communication subnet (16 VDC maximum, Class 2)

6. Accuracy:
   a. Luminosity: photodiode human eye response
   b. Motion Sensor: quad type passive infrared element with rated detection distance of 16 ft (5m)
   c. Temperature: ± 3% of full scale

7. Range:
   a. Luminosity: 0-4000 lux
   b. Motion Sensor: detection range length 94° [28.7 m], width 82° [25 m], and 64 detection zones
   c. Temperature: 41° F to 104° F (5° C to 40° C)


9. Approved Manufacturer / Model:
   a. Distech Controls

C. BLE-Enabled Intelligent Room Interface (Allure UNITOUCH)

1. Features: The BLE-Enabled Intelligent Room Interface (Allure UNITOUCH) shall communicate with any Distech Controls ECLYPSE controller and shall provide precise environmental zone values temperature, humidity, and CO2 (dependent upon sensor options selected) as well as Bluetooth low energy connectivity. Sensor options shall be provided as indicated within the sequences of operations and/or control diagrams. The backlit LCD high resolution 3.5” capacitive touchscreen display shall be capable of displaying the following elements (dependent upon sensor options and systems connected): space temperature, cooling space temperature set point, heating space temperature set point, current heating or cooling mode, current occupancy mode, fan speed, light status, blind position, alarm condition, current time, energy consumption indicator, and home and menu images can be customized. The UNITOUCH shall provide password protected menus or any other mechanism to prevent a local user to access advanced configuration menus. The UNITOUCH shall be capable of being daisy chained on controller communicating subnet via RS-485 connection and shall be locally able to pair with mobile occupant application via Bluetooth low energy connectivity. The sensor shall be designed for wall mounting.

2. Operating Temperature: 32° F to 122° F (0° C to 50° C)

3. Protection / Rating: ABS plastic housing, UL94-V0

4. Input/Output:
   a. Wired Connection – RS-485, Type T568B Cat 5e network cable (4 twisted pairs), maximum length 328 ft (100m)
   b. Wireless Communication – Bluetooth v4.2 (Frequency: 2402 – 2480 MHz)

5. Power: from controller via RS-485 communication subnet (16 VDC maximum, Class 2)
6. Accuracy:
   a. Temperature: ± 0.9° F (±0.50° C)
   b. Humidity: ± 3% of full scale
   c. CO2: 400-1250 ppm ± 30 ppm or 3% of reading, whichever is greater; 1250-2000 ppm ±5% of reading + 30ppm

7. Range:
   a. Temperature: 32° F to 122° F (0° C to 50° C)
   b. Humidity: RH 0% to 70%
   c. CO2: 0 to 2000 ppm


9. Approved Manufacturer / Model:
   a. Distech Controls

D. BLE-Enabled Intelligent Room Interface (UNIWAVE)

1. Features: The BLE-Enabled Intelligent Room Interface (UNIWAVE) shall wirelessly communicate via Bluetooth low energy with Distech Controls BLE-Enabled Multi-Sensor and shall provide precise environmental zone values temperature and humidity (dependent upon sensor options selected). Sensor options shall be provided as indicated within the sequences of operations and/or control diagrams. The E-paper 2.13” display shall be capable of displaying the following elements (dependent upon sensor options and systems connected): space temperature, cooling space temperature set point, heating space temperature set point, current heating or cooling mode, current occupancy mode, fan speed, light status, blind position, current time, and home and menu images can be customized. The UNIWAVE shall provide a local 6 button interface for local user interface to perform navigation and adjustment of points configured as adjustable. The sensor shall be adapted for use where wiring is not feasible and shall be capable of wall mounting or use as remote control.

2. Operating Temperature: 32° F to 122° F (0° C to 50° C)

3. Protection / Rating: ABS plastic housing, UL94-V0

4. Input/Output:
   a. Wireless Communication – Bluetooth v5 (Frequency: 2402 – 2480 MHz)

5. Power: 2 batteries, 1.5V AAA LR03 type, estimated battery lifetime >36 months (under typical use)

6. Accuracy:
   a. Temperature: ± 0.9° F (±0.50° C)
   b. Humidity: ± 2% of full scale

7. Range:
   a. Temperature: 32° F to 122° F (0° C to 50° C)
   b. Humidity: RH 10% to 80%

9. Approved Manufacturer / Model:
   a. Distech Controls

PART 3 - EXECUTION

3.1 COMMUNICATION BACKBONE

A. To allow for future expandability, cyber security measures, optimal bandwidth, and enhanced data trending this project shall adhere to the below communication backbone requirements.

B. Fiber Optic Network

1. Required for all project exceeding 10 levels (including rooftops/cellars), 100m between ethernet connections, 500 controllers, or more than 1 type of operational technology residing on the same network (CCTV, lighting, access, etc.).

2. BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

3. Network edge ethernet switches provided for each floor with provisions for expansion capability.

4. Fiber optic cable shall be run between aggregation switch and edge ethernet switches.

5. Must be a managed fiber / ethernet network with the following network features:
   a. Packet switching and loop detection
   b. Port security with MAC address lockdown and the ability to close all open ports including port connected to a daisy-chain of IP devices.
   c. Segregation / isolation with VLAN configuration capabilities. The system shall allow system-wide auto-creation of a VLAN simply by specifying one or more ports to be on that VLAN, and automatically ensure that traffic passes between the selected ports. There must not be any restriction on port location.
   d. Web browser based graphical user interface for information logging (network overloads, bandwidth consumption, port status, connection status, and trending)
   e. Support both Ethernet and Power over Ethernet (PoE)
   f. Support fiber optic backbone(s) with Single-strand, Single-mode Optical Fiber OS1/OS2 9/125 μm, up to 12.5 miles [20.1 km] reach
   g. BACnet protocol specific network traffic support and support for all other communication protocols
   h. Expansion capability of up to 256 Edge Ethernet Switches

6. Edge Ethernet Switch Hardware Requirements
   a. Shall provide 1 per floor
   b. Must be compatible with Centralized Ethernet Network Controller with Aggregation Switch and support the managed network features described above
c. Support Fiber Ethernet, Power over Ethernet (PoE), and Spanning Tree Protocol
d. Support all communication protocols
e. Minimum of 8 RJ45 ethernet ports (all controllers on floor must be connected to edge ethernet switch directly or via daisy-chain IP topology)

7. Ethernet Network Controller Hardware Requirements
   a. Shall provide 1 per building
   b. Must be compatible with Edge Ethernet Switches and Aggregation Switch and support the managed network features described above
   c. Support Fiber, Ethernet, Power over Ethernet (PoE), and Spanning Tree Protocol
   d. Support all communication protocols
   e. Provide network management software with management of all ports from all edge switches in a single graphical view.

8. Aggregation Switch Hardware Requirements
   a. Shall provide 1 per building
   b. Must be compatible with Edge Ethernet Switches and Aggregation Switch and support the managed network features described above
   c. Support Fiber, Ethernet, Power over Ethernet (PoE), and Spanning Tree Protocol
   d. Support all communication protocols

9. Security Provisions:
   a. Individual VLAN provided per every 2 levels

10. Acceptable Manufacturers for Fiber Network Devices:
    a. Optigo

C. IP (CAT 5 / RJ45) Network

1. Managed Ethernet Switches:
   a. Required for all projects exceeding 5 levels (including rooftops/cellars) or 250 controllers and that do NOT meet or exceed “Fiber Optic Network” requirements described above.
   b. Support for routing and VPN.
   c. Acceptable Manufacturers:
      1) Teltonika

2. Unmanaged Ethernet Switches
   a. Acceptable for all projects NOT exceeding requirements for “Fiber Optic Network” or “Managed Ethernet Switches” as described above
   b. Ethernet Switches shall be provided as needed to support a fully functional BAS – fiber network shall not be required.

D. BACnet IP

1. BACnet/IP communication protocol shall be used for all BAS manufacturer provided controllers (including terminal devices such as VAVs, FCUs, etc.)

E. Modbus RTU and BACnet MS/TP (RS-485) Network
1. Modbus RTU and BACnet MS/TP shall only be used for third party systems / equipment that do not have IP provisions (VFDs, boilers, etc.)

2. Modbus TCP shall only be used for third party systems / equipment that do not support BACnet/IP

3.2 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 ft. [9 m] of sensing element for each 1 ft² [1 m²] of coil area.

D. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

E. Install outdoor air temperature sensors on north wall at designated location with sun shield.

F. Install building pressure pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.

G. High and low limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.3 CO-ORDINATION

A. All work shall be performed at times acceptable to the Engineer/Construction Manager. Provide work schedule at the start of the job for the approval of the Engineer / Construction Manager. Schedule shall show when all staff and sub-contractors shall be on-site.

3.4 ELECTRICAL WORK, WIRING AND SAFETY

A. Electrical work shall be in accordance ANSI/NFPA 70 and the local Electrical Code.

B. Based on project location, Regional Regulation Compliance Certifications (CSA C22.1) will be required.

C. Electrical wiring, terminal blocks and other high voltage contacts shall be fully enclosed or properly guarded and marked to prevent accidental injury to personnel.

D. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26 00 00, and manufacturer's recommendations. Where the requirements of this Section differ from other Divisions, this Section shall take precedence.
1. Power wiring to mechanical equipment, variable air volume boxes, and motor controllers shall be provided by the Electrical contractor (Division 26).

2. EMT conduit shall be used in mechanical/electrical rooms and exposed spaces.

3. Rigid Galvanized Steel conduit shall be used outdoors.

4. Plenum rated cable shall be used in concealed spaces/hung ceilings.

E. All wiring associated with and required by the BAS shall be the responsibility of this contractor.

1. The term "wiring" shall be construed to include furnishing of wire, conduit, and miscellaneous material and labor as required to install a total working system.

2. If departures from the contract documents are deemed necessary by the contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be submitted with the drawings to the Engineer for approval.

F. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

G. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

H. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

I. Each run of communication wiring shall be a continuous length without splices when that length is commercially available.

J. Label communication wiring to indicate origination and destination.

K. Fiber optic cable shall comply with the following requirements:

1. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125 µm.

2. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

3.5 SUBMITTALS

A. Schematic diagram of each controlled system. Label control points with point names.

B. Bill of Material for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
C. Specification sheets for each item including manufacturers descriptive literature, drawings, diagrams, performance and characteristic curves, manufacturer and model number, size, layout, dimensions, capacity, etc.

D. Control schematics with narrative description and control descriptive logic fully showing and describing operation and/or manual procedures available to operating personnel to achieve proper operation of the building, including under complete failure of the BAS.

E. Shop drawings for each input/output point showing all information associated with each particular point including sensing element type and location; details of associated field wiring schematics and schedules; point address; software and programming details associated with each point; and manufacturer's recommended installation instructions and procedures for each type of sensor and/or transmitter.

F. Riser diagrams showing control network layout, communication protocol, and wire types.

G. Network diagram of control, communication, and power wiring for BAS Server and OWS installation.

3.6 AS-BUILT DOCUMENTATION

A. As-built documentation shall consist of 4 hard copies and one soft copy for all information described below

B. The final documentation package shall include:

1. As-built Submittals: Final as built control submittals and technical data sheets.

2. Programming, Sequences, and Graphics: All programming, sequences, and graphics saved to an external hard drive.

3. Operation and Maintenance Manuals: Factory operating and maintenance manuals with any customization required.

4. Test Procedures and Reports: The test implementation shall be recorded with a description of the test exercise script of events and documented as test procedures.

3.7 WARRANTY

A. The BAS system labor and materials shall be warranted free from defects for a period of 1 year(s) after final commissioning and owner acceptance.

3.8 TRAINING

A. BAS Contractor shall provide a minimum of 16 hours of training with course outline and materials for personnel designated by the owner.
B. If desired manufacturer provided training on the use and operation of all products provided within these specifications shall be available for purchase and attendance by the Owner or his designated agent. A list of training courses with detailed course outline and duration with the associated cost shall be provided as part of the BAS submittals.

3.9 BALANCING AND COMMISSIONING

A. BAS Contractor shall provide a minimum of 16 hours of commissioning assistance with a commissioning agent and 16 hours of balancing assistance with a balancing agent. Balancing and commissioning agents shall NOT be provided by BAS contractor – BAS contractor is responsible for assistance only.

B. For projects without balancing and commissioning agents the BAS contractor shall self commission the system utilizing the allotted hours stated above.

C. For projects including gas detection / air quality sensors involved in life safety operations a minimum of 8 hours shall be provided within BAS scope of work for the gas sensor manufacturer to provide checkout, calibration, and owner training.

D. Provide commissioning data sheets prior to acceptance testing.

3.10 ALTERNATES

A. Maintenance Contract:

1. The BAS Contractor shall present a two year maintenance contract for the Owner's acceptance within sixty days after installation of the system begins. Show the price for each year with all payment terms and conditions.

2. The Maintenance Contract shall include the following provisions: on-line diagnostic and troubleshooting service, quarterly software maintenance/consultation/database backup, repair and replacement as needed (T&M proposals), and emergency service (per predetermined agreement).

3. Maintenance Routines include, but are not be limited to the following: checking performance of equipment and components (with diagnostic testing, examination, adjustment, and calibration) and 2 training sessions per year.

4. The Maintenance Contract shall be renewable at the Owner’s option and include provision for increased charges due to expansion of the system, changes in service coverage, and/or inflation.

END OF SECTION 230900
SECTION 260500 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 CONDITIONS AND REQUIREMENTS

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

B. Provisions of this Section shall apply to all Sections of Division 26, 27, and 28.

1.2 SCOPE OF WORK

A. Furnish and install all materials and equipment and provide all labor required and necessary to complete the work shown on the drawings and/or specified in all Sections of Division 26 and all other work and miscellaneous items, not specifically mentioned, but reasonably inferred for a complete installation, including all accessories required for testing the system. It is the intent of the drawings and specifications that all systems be complete and ready for operation.

1.3 CODE COMPLIANCE

A. All work and materials shall comply with the latest rules, codes and regulations, including, but not limited to, the following:

1. Occupational Safety and Health Act Standards (OSHA)
2. NFPA #70 – National Electric Code (NEC)
3. ADA Standards – Americans with Disabilities Act
5. NECA – Standard of Installation
7. International Fire Code
9. NFPA #72 – Fire Code
11. All other applicable Federal, State and local laws and regulations.

B. Work to be executed and inspected in accordance with local codes and ordinances. Permits, fees or charges for inspection or other services shall be paid for by the contractor. Local codes and ordinances are to be considered as minimum requirements and must be properly executed without expense to the owner; but do not relieve the contractor from work shown that exceeds minimum requirements.
1.4 CONDITIONS AT SITE

A. Visit to site is recommended of all bidders prior to submission of bid. All will be held to have familiarized themselves with all discernible conditions and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.

B. Lines of other service that are damaged as a result of this work shall be promptly repaired at no expense to the owner to the complete satisfaction of the owner.

1.5 DRAWINGS AND SPECIFICATIONS

A. All drawings and all specifications shall be considered as a whole, and work of this Division shown anywhere therein shall be furnished under this Division.

B. Drawings are diagrammatic and indicate the general arrangement of equipment and wiring. Most direct routing of conduits and wiring is not assured. Exact requirements shall be governed by architectural, structural and mechanical conditions of the job. Consult all other drawings in preparation of the bid. Extra lengths of wiring or addition of pull or junction boxes, etc., necessitated by such conditions shall be included in the bid. Check all information and report any apparent discrepancies before submitting bid.

C. Change to location, type, function, brand name, finish, etc., shall not be made without permission of engineer.

D. Some equipment is specifically designated on the drawings. It is not the intent to sole source any item unless explicitly stated. Items have been specified based upon design requirements. All bidders are encouraged to submit products for approval. Prior approval must be obtained as required by these contract documents. Bids submitted with non-approved items will be considered invalid and bidders will be held to provide approved materials at no additional cost to the owner. Submittals received by the engineer after award of contract on non-approved equipment will not be reviewed nor will they be returned.

E. Where conflicting direction is given within the specifications and drawings, the contractor shall include the most expensive option in the bid.

1.6 SAFETY AND INDEMNITY

A. Safety: The contractor shall be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours.

B. No act, service, drawing review or construction review by the owner is intended to include review of the adequacy of the contractor’s safety measures in, on, or near the construction site.

1.7 CONSTRUCTION OBSERVATION BY THE ENGINEER

A. Prior to covering: any major portion of the materials installed under this section, notify the engineer so that an observation can be made. Notification shall be made at least three (3) working days in advance of the date the items will be covered.
1.8 INSTRUCTION OF OWNER’S PERSONNEL

A. The contractor shall conduct an on-site instructional tour of the entire project. The personnel designated by the owner shall be instructed in: operation of all electrical systems, trouble-shooting procedures, preventative maintenance procedures, uses of Operation and Maintenance manuals, maintenance and cleaning of lighting fixtures and operation of all special systems.

1.9 PROJECT COMPLETION

A. Upon completion of all work and operational checks on all systems, the contractor shall request that a final construction observation be performed.

B. The engineer shall compile a punch list of items to be completed or corrected. The contractor shall notify the engineer upon completion of the items.

1.10 GUARANTEE

A. All work under this section shall be guaranteed in writing to be free of defective work, materials, or parts for a period of one (1) year after final acceptance of the work under this contract or the period indicated under the Division 1 specifications whichever is longer.

B. Repair, revision or replacement of any and all defects, failure or inoperativeness shall be done by the contractor at no cost to the owner.

PART 2 - PRODUCTS

2.1 MATERIAL APPROVAL

A. The design, manufacturer and testing of electrical equipment and materials shall conform to or exceed latest applicable NEMA, IEEE or ANSI standards.

B. All materials must be new, unless noted otherwise, and UL listed. Materials that are not covered by UL testing standards shall be tested and approved by an independent testing laboratory or a governmental agency, which laboratory shall be acceptable to the owner and code enforcing agency.

2.2 SHOP DRAWINGS AND MATERIALS LIST

A. Submit an electronic copy, unless noted otherwise under Division 1, of the Division 26, 27 and 28 shop drawings and material lists proposed for this project to the architect/engineer for review.

2.3 OPERATION AND MAINTENANCE MANUALS

A. Submit an electronic copy, unless noted otherwise under Division 1, of the Operation and Maintenance Manuals for all Division 26, 27 and 28 equipment to the architect/engineer.
2.4 RECORD DRAWINGS
   A. Submit record drawings to owner.

2.5 PRODUCT DELIVERY, STORAGE AND HANDLING
   A. Deliver, store, and handle materials in a manner to prevent damage.
   B. Protect equipment from weather and dampness.

PART 3 - EXECUTION

3.1 WORKMANSHIP AND CONTRACTOR’S QUALIFICATIONS
   A. Only quality workmanship will be accepted. Haphazard or poor installation practice will be cause for rejection of work.
   B. Provide experienced foreman with a minimum of three years experience working on this type of building placed in charge of this work at all times.

3.2 COORDINATION
   A. Coordinate work with other trades to avoid conflict and to provide correct rough-in and connection for equipment furnished under trades that require electrical connections. Inform contractors of other trades of the required access to and clearances around electrical equipment to maintain serviceability and code compliance.
   B. Verify equipment dimensions and requirements with provisions specified under this Section. Check actual job conditions before fabricating work. Report necessary changes in time to prevent needless work. Changes or additions subject to additional compensation, which are made without the authorization of the owner, shall be at contractor’s risk and expense.

3.3 MANUFACTURER’S INSTRUCTIONS
   A. All installations are to be made in accordance with manufacturer’s recommendations. A copy of such recommendations shall at all times be kept in the job superintendent’s office and shall be available to the engineer.
   B. Follow manufacturer’s instructions where they cover points not specifically indicated on drawings and specifications. If they are in conflict with the drawings and specifications obtain clarification from the engineer before starting work.

3.4 QUALITY ASSURANCE
   A. The contractor shall insure that all workmanship, all materials employed, all required equipment and the manner and method of installation conforms to accepted construction and engineering practices,
and that each piece of equipment is in satisfactory working condition to satisfactorily perform its functional operation.

B. Provide quality assurance tests and operational check on all components of the electrical distribution system, all lighting fixtures, and special systems.

3.5 CUTTING AND PATCHING

A. Perform all cutting and fittings required for work of this section in rough construction of the building.

B. All patching of finished construction of building shall be performed under the sections of specifications covering these materials.

C. No joists, beams, girders or columns shall be cut by any contractor without obtaining written permission from the architect/engineer.

END OF SECTION 260500
SECTION 260519 - CONDUCTORS AND CABLES

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 SUMMARY
   A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

1.3 SUBMITTALS
   A. Submit shop drawings and product data.

1.4 COORDINATION
   A. Coordinate layout and installation of cables with other installations.
   B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by the owner.

PART 2 - PRODUCTS

2.1 BUILDING WIRES AND CABLES
   A. Conductors: Stranded, copper, 600-volt insulation, type THHN/THWN, THHN/THWN-2, XHHN/XHHW.
   B. Conductors:
      1. Solid or stranded for No. 10 and smaller, stranded for No. 8 and larger, copper, 600-volt insulation, type THHN/THWN. Aluminum conductors not allowed unless noted otherwise.
      2. Insulation Types: THWN-2 for underground, THWN for wet locations, THHN for dry locations; XHHN/XHHW for GFI branch circuits and feeders fed from GFCI breakers.
   C. Color-code 208/120-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
      1. Phase A: Black.
      2. Phase B: Red.
3. Phase C: Blue.
5. Ground: Green.
6. Isolated ground: Green with yellow tracer.

D. Color-code 480/277-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:

1. Phase A: Brown.
2. Phase B: Orange.
3. Phase C: Yellow.
5. Ground: Green.

E. Wire connectors and splices: units of size, ampacity rating, material, type and class suitable for service indicated.

F. Signal and communication circuits:

1. Special cables as indicated on the drawings.
2. Conductors for general use: stranded copper conductor, #16 AWG minimum, with THWN-2 insulation for underground, THWN for wet locations and THHN insulation for dry locations.

PART 3 - EXECUTION

3.1 GENERAL WIRING METHODS

A. Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Use no wire smaller than #12 AWG for power and lighting circuits and no smaller than #18 AWG for control wiring.

C. The contractor is responsible for upsizing conductor sizes to ensure the maximum voltage drop of any branch circuit does not exceed 3%. For reference, use No. 10 AWG conductor for 20 Amp, 120 volt branch circuits longer than 75 feet, and for 20 Amp, 277 volt branch circuits longer than 200 feet.

D. Place an equal number of conductors for each phase of a circuit in the same raceway or conduit.

E. Splice only in junction or outlet boxes.

F. Neatly train or lace wiring inside boxes, equipment, and panelboards.

G. Make conductor lengths for parallel circuits equal.

H. Provide a separate neutral conductor for each ungrounded conductor. Ungrounded conductors may share a neutral when all of the following conditions are met:
1. The ungrounded conductors are connected to a multi-pole breaker or breakers that are clipped together with a UL listed means that provide a common trip.
2. The ungrounded conductors contained in the same conduit or raceway.
3. The ungrounded conductors all originate from a separate and unique phase bus in the panel.

3.2 INSTALLATION
A. Install wires and cables as indicated, according to manufacturer's written instructions, and the “National Electrical Installation Standards” by NECA.
B. Remove existing wires from raceway before pulling in new wires and cables.
C. Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
D. Use pulling means; including fish tape, cable, rope, and basket weave wire/cable grips that will not damage cables or raceway.
E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
F. Support cables above accessible ceilings; do not rest on ceiling tiles. Do not fasten cables to ceiling support wires. Use cable ties to support cables from structure.

3.3 CONNECTIONS
A. Conductor Splices: Keep to minimum.
B. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced.
C. Use splice and tap connectors compatible with conductor material.
D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.
E. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.
F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values.
G. Terminate spare conductors with electrical tape.

3.4 LABELING
A. Provide Brady wire markers or equivalent on all conductors. All wire shall be labeled in each box and panel with the circuit number and panel identification.
3.5 FIELD QUALITY CONTROL

A. Inspect wire and cable for physical damage.

B. Perform continuity testing on all power and equipment branch circuit conductors. Verify proper phasing connections.

END OF SECTION 260519
SECTION 260526 - GROUNDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Fixed Price Construction Contract and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 SYSTEM DESCRIPTION

A. Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductors in raceways and cables, receptacle ground connectors, and plumbing systems.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Section 260519 - Conductors and Cables.

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated with green-colored insulation. Where green insulation is not available, on larger sizes, black insulation shall be used and suitably identified with green tape at each junction box or device enclosure.

2.2 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.
PART 3 - EXECUTION

3.1 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NEC Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NEC are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.

D. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways bonded to outlet or equipment, sized per Section 250 of the NEC.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

3.4 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

C. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values.

3.5 EQUIPMENT GROUND

A. Ground non-current carrying metal parts of electrical equipment enclosures, frames, conductor raceways or cable trays to provide a low impedance path for line-to-ground fault current and to bond all non-current carrying metal parts together. Install a grounding conductor in each raceway system. Equipment grounding conductor shall be electrically and mechanically continuous from the electrical circuit source to the equipment to be grounded. Size grounding conductors per NEC 250 unless otherwise shown on the drawings.

B. Install metal raceway couplings, fittings, and terminations secure and tight to ensure good grounding continuity. Provide grounding conductor sized per NEC through all raceway and conduit systems.

C. Lighting fixtures shall be securely connected to equipment grounding conductors. Outdoor lighting standards shall have a factory installed ground lug for terminating the grounding conductor.

D. Motors shall be connected to equipment ground conductors with a bolted solderless lug connection on the metal frame.

3.6 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

END OF SECTION 260526
SECTION 260533 - RACEWAYS AND BOXES

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 SUMMARY
   A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS
   A. EMT: Electrical metallic tubing.
   B. FMC: Flexible metal conduit.
   C. IMC: Intermediate metal conduit.
   D. LFMC: Liquidtight flexible metal conduit.
   E. RMC: Rigid metal conduit.
   F. RNC: Rigid Polyvinyl Chloride conduit.
   G. PVC: Rigid Polyvinyl Chloride conduit
   H. HDPE: High Density Polyethylene Conduit

1.4 SUBMITTALS
   A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 COORDINATION
   A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.

PART 2 - PRODUCTS
2.1 METAL CONDUIT AND TUBING
   A. Rigid Steel Conduit: ANSI C80.1.
   B. IMC: ANSI C80.6.
   C. PVC coated Steel Conduit and Fittings: NEMA RN 1; rigid steel conduit with external 40 mil PVC coating and internal two mil urethane coating.
   D. EMT and Fittings: ANSI C80.3. Fittings: Set-screw type.
   E. FMC: Zinc-coated steel.
   F. LFMC: Flexible steel conduit with PVC jacket. Fittings: NEMA FB 1; compatible with conduit/tubing materials.

2.2 NONMETALLIC CONDUIT AND TUBING
   A. RNC: NEMA TC 2, Schedule 40 PVC. Fittings: NEMA TC 3; match to conduit and material.

2.3 METAL WIREWAYS
   A. Material: Sheet metal sized and shaped as indicated.
   B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
   C. Finish: Manufacturer's standard enamel finish.

2.4 OUTLET AND DEVICE BOXES
   A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.
   B. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.

2.6 PULL AND JUNCTION BOXES
   A. Small Sheet Metal Boxes: NEMA OS 1, galvanized steel.
   B. Cast-Metal Boxes: NEMA FB 1, cast aluminum with gasketed cover.

2.7 ENCLOSURES AND CABINETS
   A. Hinged-Cover Enclosures: NEMA 250, Type 1, 3R, or 4, with continuous hinge cover and flush latch, key operable.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

B. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 WIRING METHODS

A. Outdoors: Use the following wiring methods:

1. Exposed: Rigid steel or IMC.
2. Concealed: Rigid steel or IMC.
3. Underground, Single Run: RNC or PVC Externally Coated Rigid Steel Conduit where required by NEC 517.13.
4. Underground, Grouped: RNC or PVC Externally Coated Rigid Steel Conduit where required by NEC 517.13.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.

B. Indoors: Use the following wiring methods:

1. Exposed: EMT or “Wiremold” metallic raceways or equal.
2. Exposed in public areas: “Wiremold” metallic raceways or equal. Use of exposed raceways in public areas must be approved by the architect prior to installation for each location. Use of exposed EMT in areas visible to the public is not allowed unless specifically approved by the architect prior to installation. Replacement of unapproved installations of exposed raceways will be at the expense of the contractor if deemed necessary by the architect or engineer.
3. Concealed: EMT or MC-Cable. Note: MC-Cable is not approved for “homeruns”
4. Concealed in Patient Care Areas: EMT or Hospital Grade MC-Cable where allowed by code. Note: Hospital Grade MC-Cable is not approved for “homeruns”
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except in wet or damp locations, use LFMC.
6. Damp or Wet Locations: Rigid steel conduit.
7. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
   a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.
3.3 INSTALLATION

A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions.

B. Minimum Raceway Size: 1/2-inch trade size. 3/4-inch minimum for “homeruns”.

C. Conceal conduit and EMT, unless otherwise indicated, within finished walls, ceilings, and floors.

D. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

E. Install raceways level and square and at proper elevations. Provide adequate headroom.

F. Complete raceway installation before starting conductor installation.

G. Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.

H. Use temporary closures to prevent foreign matter from entering raceways.

I. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

J. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

K. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

L. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

M. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.

1. Run parallel or banked raceways together, on common supports where practical.
2. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

O. Join raceways with fittings designed and approved for the purpose and make joints tight.

1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
2. Use insulating bushings to protect conductors.

P. Tighten set screws of threadless fittings with suitable tools.

Q. Terminus: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.
R. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple so no threads are exposed.

S. Install pull wires in empty raceways. Utilize polyester line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of the pull wire.

T. Telephone and Signal System Raceways: In addition to the above requirements, install raceways in maximum lengths of 150 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements.

U. Install raceway sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as the boundaries of refrigerated spaces.
2. Where conduit pass from the interior to the exterior of a building.
3. Where otherwise required by NEC.

V. Apply firestopping to cable and raceway penetrations of fire-rated floor, ceiling, and wall assemblies to achieve fire-resistance rating of the assembly. Boxes installed in fire-rated floor, ceiling, and wall assemblies shall result in no larger than a 16 square-inch penetration in the fire-rated wall surface and the quantity of penetrations shall not be greater than 100 square-inches for every 100 square feet of fire-rated wall area. Where boxes are located on both sides of a fire-rated wall, the boxes shall have a minimum of a 24" horizontal spacing, where a 24" horizontal spacing cannot be achieved, furnish and install listed fire-rated putty on the boxes as required by the IBC.

W. Route conduit through roof openings for piping and ductwork where possible; otherwise, install roof penetrations in accordance with roofing system requirements. Coordinate with roofing installer.

X. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded flush plugs flush with floor for future equipment connections.

Y. Flexible Connections: Use maximum of 6 feet of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.

Z. PVC Externally Coated, Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.

AA. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying the raceways to receptacle or fixture ground terminals.

BB. Conduits shall not be routed on or above the roof without prior approval from the Engineer. Instead, the branch circuits shall be routed at the structure level below the roof to feed roof-top
equipment. When approval is granted to route conduits on or above the roof, the conduits shall be strapped to COOPER industries DB series support blocks at intervals not exceeding NEC requirements. The conduits shall not be rested directly on the roof. It shall be permissible to penetrate the roof adjacent mechanical or electrical equipment to power that respective equipment.

3.4 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.

C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers, at least every 8 feet.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 1/4-inch diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Simultaneously install vertical conductor supports with conductors.

J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.

K. Install metal channel racks for mounting cabinets, panelboards; disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Do not fasten supports to piping, ductwork, mechanical equipment, or conduit. Perform fastening according to the following unless other fastening methods are indicated:
1. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
2. New Concrete: Concrete inserts with machine screws and bolts.
3. Existing Concrete: Expansion bolts.
4. Steel: Spring-tension clamps on steel.
5. Light Steel: Sheet-metal screws.
6. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-
test load.

N. Do not drill structural steel members.

O. All supports and attachments shall meet project seismic zone requirements.

3.5 BOX INSTALLATION

A. Do not install boxes back-to-back in walls.

B. Locate boxes in masonry walls to require cutting of masonry unit edge only. Coordinate masonry
cutting to achieve neat openings for boxes.

C. Provide knockout closures for unused openings.

D. Support boxes independently of conduit except for cast boxes that are connected to two rigid metal
conduits, both supported within 12 inches of box.

E. Use 4” boxes with multiple-gang mud-ring where more than one device are mounted together; do
not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

F. Install boxes in walls without damaging wall insulation.

G. Coordinate mounting heights and locations of outlets mounted above counters, benches, and
backsplashes.

H. Position outlets to locate lighting fixtures as shown on reflected ceiling plans.

I. In inaccessible ceiling areas, position outlets and junction boxes within 6 inches of recessed
luminaire, to be accessible through luminaire ceiling opening.

J. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs,
accurately positioning to allow for surface finish thickness. Use stamped steel stud bridges for flush
outlets in hollow stud walls, and adjustable steel channel fasteners for flush ceiling outlet boxes.

K. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

L. For boxes installed in metal construction, use rigid support metal bar hangers or metal bar fastened
to two studs or with metal screws to metal studs.

M. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

N. Locate pull and junction boxes above accessible ceilings or in unfinished areas. Support pull and
junction boxes independent of conduit.
3.6 LABELING

A. Label coverplate of all pull and junction boxes by system served. Indicate panel circuits for power and lighting boxes.

3.7 CLEANING

A. On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.

END OF SECTION 260533
SECTION 262813 - FUSES

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 SUMMARY
   A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, starters, and motor control centers; and spare fuse cabinets.

1.3 SUBMITTALS
   A. Product Data: Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

1.4 QUALITY ASSURANCE
   A. Source Limitations: Provide fuses from a single manufacturer.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the NEC, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   C. Comply with NEMA FU 1.
   D. Comply with the NEC.

1.5 PROJECT CONDITIONS
   A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION
   A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.

1. Fuses: Furnish one set of three of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

2. Gould Shawmut.
4. Or approved equal.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 262813
SECTION 262815 - DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.

1.2 WORK INCLUDED
   A. Provide and install motor disconnects.
   B. Provide and install circuit disconnects.

1.3 REFERENCES
   A. Underwriters' Laboratory, Inc. - Annual Product Directories.
   B. NEMA - Classification of Standard Types of Nonventilated Enclosures for Electric Controllers.

1.4 REGULATORY REQUIREMENTS
   A. Conform to National Electrical Code and to applicable inspection authority.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
   A. Cutler-Hammer/Westinghouse, General Electric, Siemens, Square D, or approved equal.

2.2 COMPONENTS
   A. Motor and circuit disconnects shall have an Underwriters' Laboratory label.
   B. Single Phase 120 Volt Disconnect Switches: Single pole toggle switch with thermal overload motor protection where indicated. A Horse Power rated switch may be used where fractional horse power motors have internal overload protection.
   C. Single or Three Phase Motor Disconnect Switches: two or three pole heavy duty or fusible where other loads are on same circuit, 250 or 600 volt as required in NEMA Type 1, 3R, or 4 enclosures designed to reject all except Class 'R' fuses.
2.3 ACCEPTABLE MANUFACTURERS - FUSES
   A. Cooper Bussmann, Edison, Littelfuse, Ferraz Shawmut, or approved equal.

2.4 FUSES
   A. As indicated on the drawings. All shall be of the same manufacturer. Provide one spare set of fuses (minimum of three) for each current rating and type used.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Install motor and circuit disconnect as indicated on Drawings and as required by Code. Where fuses are indicated, provide fuses correlated with full load current of motors provided.

END OF SECTION 262815