

Exhibit A

DRAWING INDEX			
DRAWING NUMBER	SHEET TITLE	09/17/2019 90% CONSTRUCTION DOCUMENTS	01/17/2020 100% CONSTRUCTION DOCUMENTS
GENERAL DRAWINGS			
COVER	TITLE SHEET, VICINITY MAP, SITE LOCATION MAP, & DRAWING INDEX	X	X
MECHANICAL DRAWINGS			
M0.1	HVAC & PIPING LEGEND, ABBREVIATIONS, & GENERAL NOTES	X	X
M1.1	FIRST FLOOR PLAN – HVAC DEMOLITION WORK	X	X
M2.1	FIRST FLOOR PLAN – HVAC NEW WORK	X	X
M3.1	HVAC SCHEDULES	X	X
M4.1	HVAC DETAILS	X	X
ELECTRICAL DRAWINGS			
E0.1	SYMBOLS LEGEND & GENERAL NOTES	X	X
E1.0	EXISTING ONE-LINE DIAGRAM	X	X
E2.1	FIRST FLOOR – ELECTRICAL DEMOLITION PLAN	X	X
E3.1	FIRST FLOOR – MECHANICAL POWER PLAN	X	X



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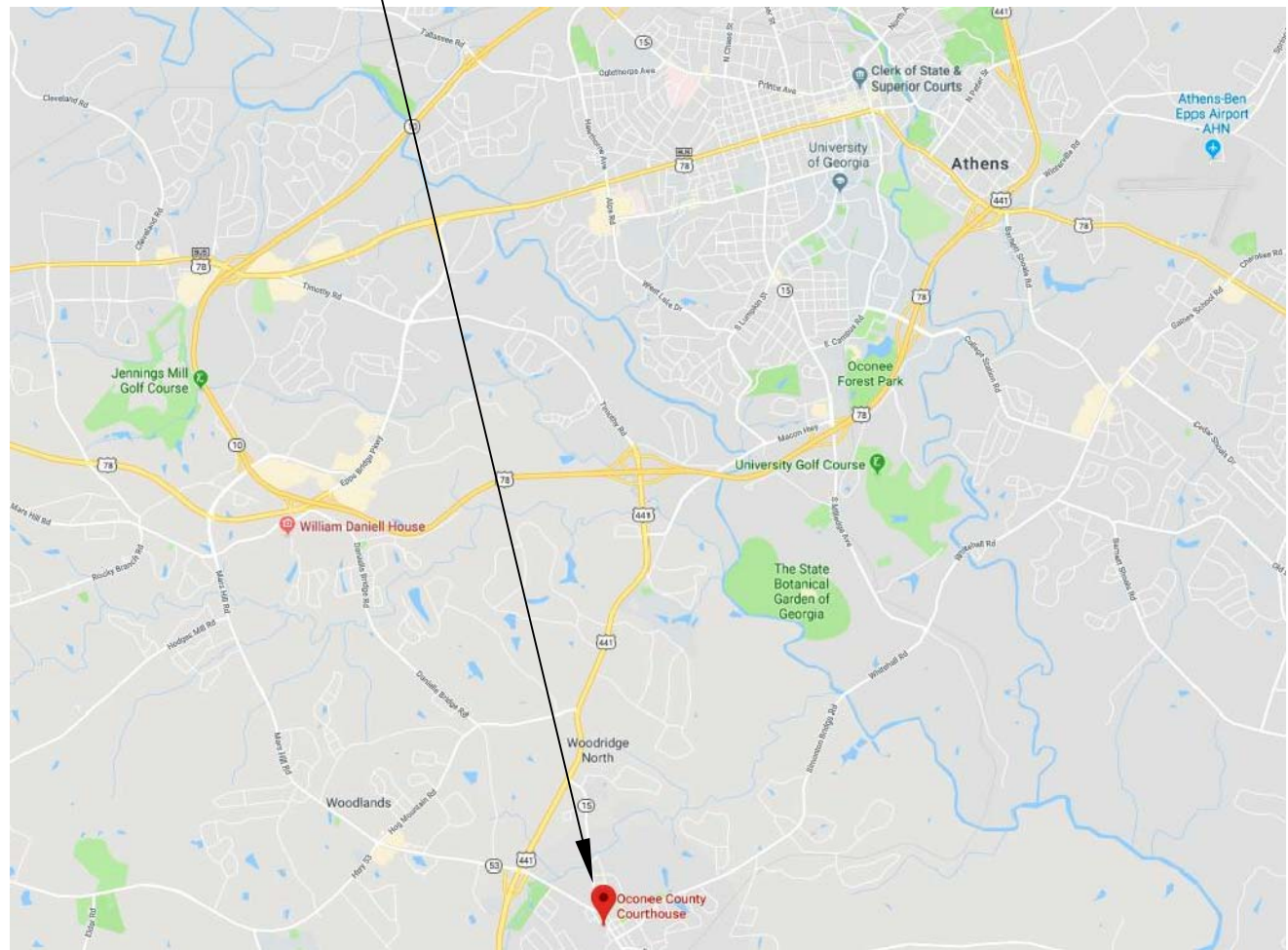


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OCONEE COUNTY COURTHOUSE HVAC RENOVATION AND REPLACEMENT FIRST FLOOR WATER SOURCE HEAT PUMPS

23 NORTH MAIN STREET
WATKINSVILLE, GA 30677

OCONEE COUNTY COURTHOUSE
WATKINSVILLE, GA.



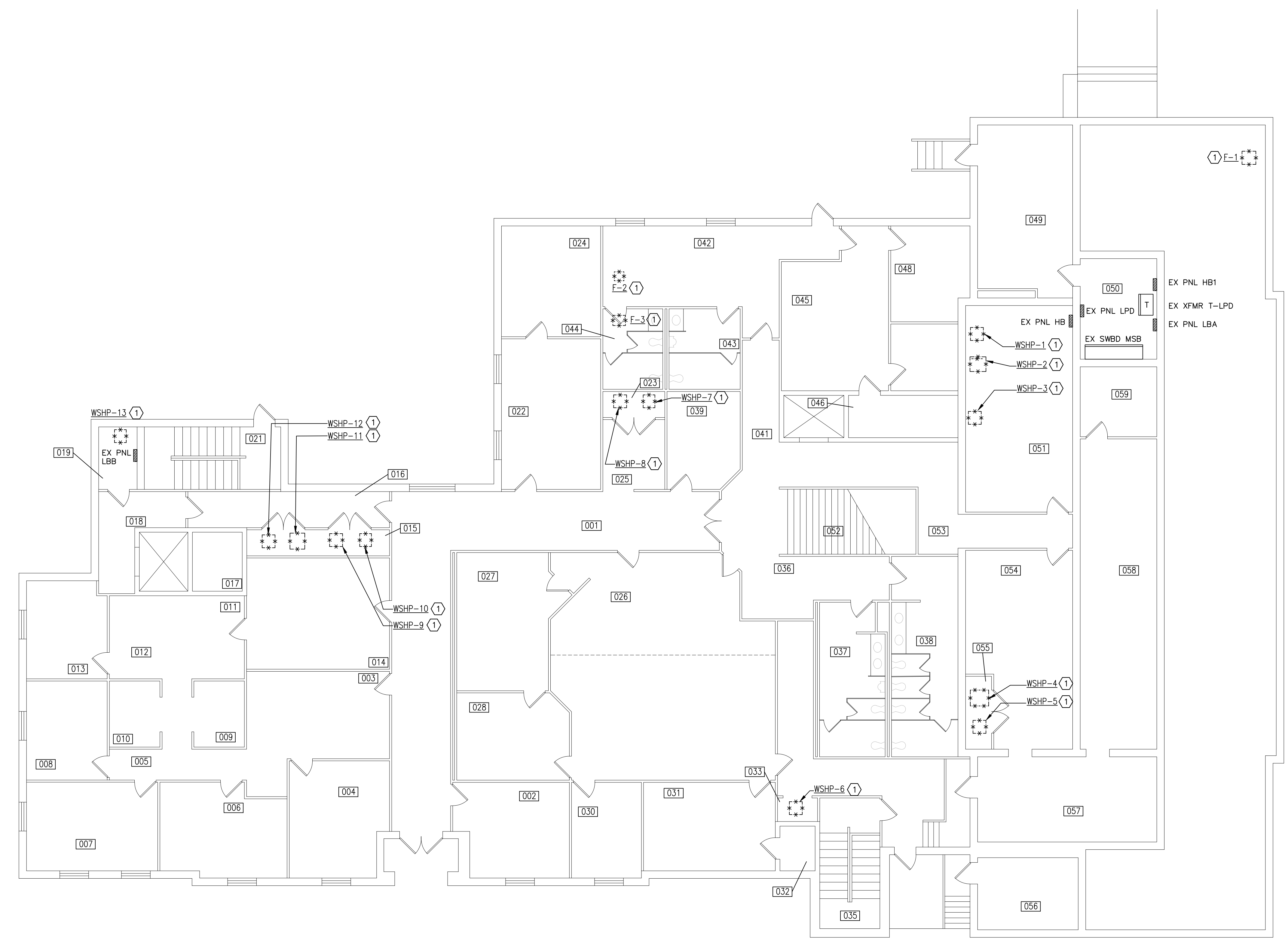
VICINITY MAP
SCALE: NOT TO SCALE

PROJECT SITE



SITE LOCATION MAP
SCALE: NOT TO SCALE

OCONEE COUNTY COURTHOUSE
HVAC RENOVATION AND REPLACEMENT
FIRST FLOOR WATER SOURCE HEAT PUMPS
 23 NORTH MAIN STREET
 WATKINSVILLE, GA 30677



GENERAL NOTES: (THIS SHEET ONLY, EXCEPT AS NOTED)

1. MATERIALS EXPOSED WITHIN PLENUMS ARE REQUIRED TO BE NONCOMBUSTIBLE OR SHALL HAVE A FLAME SPREAD INDEX OF NOT MORE THAN 25 AND A SMOKE-DEVELOPED INDEX OF NOT MORE THAN 50 AS DETERMINED IN ACCORDANCE WITH ASTM E 84 EXCEPT FOR TESTED AND LABELED WIRING, FIRE SPRINKLER PIPING, PNEUMATIC TUBING, AND ELECTRICAL EQUIPMENT. (IBC SECTIONS 716.5 AND 1017.4.1; IMC SECTION 602.2.1)
2. REFER TO MECHANICAL DRAWINGS FOR EXACT DUCT DETECTOR MOUNTING LOCATION AND QUANTITIES. (TYPICAL)

FIRST FLOOR - ELECTRICAL DEMOLITION PLAN
 1 E2-1 SCALE: 1/8" = 1'-0"

KEYNOTES: (THIS SHEET ONLY, EXCEPT AS NOTED)

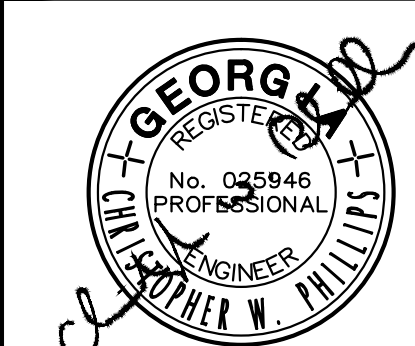
- 1 DISCONNECT EXISTING MECHANICAL EQUIPMENT SCHEDULED TO BE REPLACED BY MECHANICAL DIVISION. REMOVE EXISTING ASSOCIATED DISCONNECT. LOCK-OUT EXISTING CIRCUIT AND MAKE READY FOR RECONNECTION TO NEW EQUIPMENT. COORDINATE DISCONNECTION AND RECONNECTION WITH MECHANICAL DIVISION PRIOR TO COMMENCING ANY WORK.



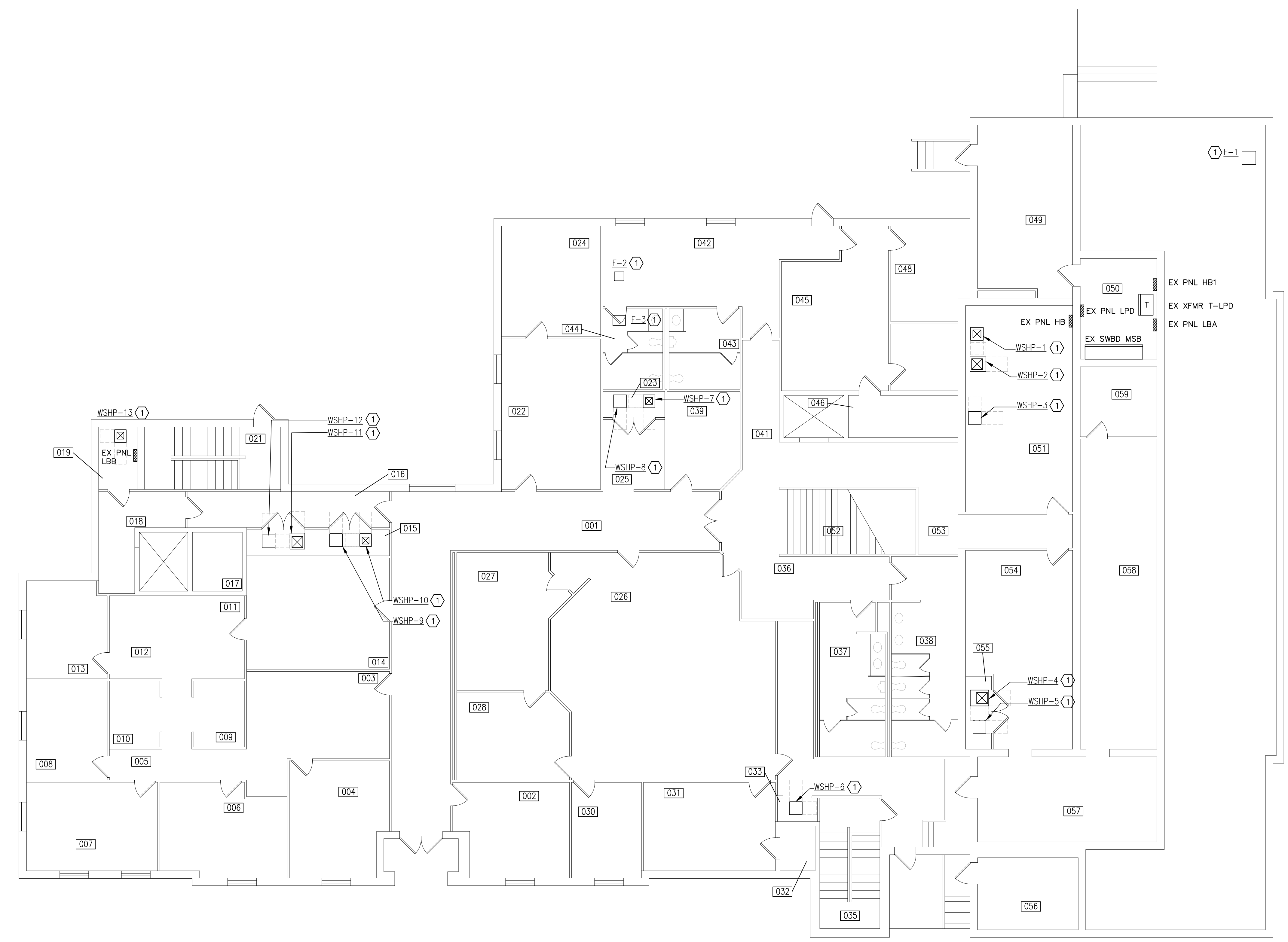
NO.	REVISIONS	DATE

FIRST FLOOR - ELECTRICAL DEMOLITION PLAN

JOB NUMBER	19J549
DRAWN BY	CAD
CHECKED BY	RVG
DATE	01/17/2020
DRAWING NUMBER	E2-1



OCONEE COUNTY COURTHOUSE
HVAC RENOVATION AND REPLACEMENT
FIRST FLOOR WATER SOURCE HEAT PUMPS
 23 NORTH MAIN STREET
 WATKINSVILLE, GA 30677



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2. REFER TO MECHANICAL DRAWINGS FOR EXACT DUCT DETECTOR MOUNTING LOCATION AND QUANTITIES. (TYPICAL)

FIRST FLOOR - MECHANICAL POWER PLAN
 SCALE: 1/8" = 1'-0"

KEYNOTES: (THIS SHEET ONLY, EXCEPT AS NOTED)

- ① RECONNECT NEW MECHANICAL EQUIPMENT SCHEDULED TO REPLACE EXISTING EQUIPMENT IN PLACE BY MECHANICAL DIVISION. NEW MECHANICAL EQUIPMENT IS SCHEDULED TO HAVE INTEGRAL DISCONNECT SWITCH. COORDINATE EQUIPMENT RECONNECTION WITH MECHANICAL DIVISION PRIOR TO COMMENCING ANY WORK. CONTRACTOR SHALL VERIFY CIRCUIT LOADING PRIOR TO ROUGH-IN AND RECONNECTION.

NO.	REVISIONS	DATE

FIRST FLOOR - MECHANICAL POWER PLAN

JOB NUMBER	19J549
DRAWN BY	CAD
CHECKED BY	RVG
DATE	01/17/2020
DRAWING NUMBER	E3-1





100% Construction Documents for:

Oconee County Courthouse

HVAC Renovation and Replacement

First Floor Water Source Heat Pumps

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CONTENTS**DIVISION 23 – HEATING, VENTILATION, AND AIR CONDITIONING**

23 0010	General Provisions – HVAC
23 0100	Operation and Maintenance of HVAC Systems
23 0500	Common Work Results for HVAC
23 0514	Variable Frequency Drives
23 0523	Mechanical Valves and Strainers
23 0529	Supports and Anchors
23 0549	Vibration Isolation
23 0553	Identification for HVAC Piping and Equipment
23 0595	Boiler Testing
23 0700	Mechanical Insulation
23 0933	Electrical Controls Systems
23 2000	Pipe, Fittings and Accessories – Mechanical
23 2210	Compressed Air Piping

DIVISION 26 – ELECTRICAL

260500	Common Work Results For Electrical
260501	Basic Materials And Methods
260502	Existing Conditions
260513	Medium-Voltage Cables
260519	Low-Voltage Electrical Power Conductors And Cables
260526	Grounding And Bonding For Electrical Systems
260534	Conduit
260535	Boxes
260543	Underground Ducts And Raceways For Electrical Systems
260548	Vibration And Seismic Controls For Electrical Systems
260563	Identification For Electrical Systems
261319	Medium-Voltage Metal-Clad Switchgear
262405	Distribution Equipment Testing
262406	New Overcurrent Devices In Existing Equipment
262416	Power Distribution Panelboard
262726	Wiring Devices
262800	Low-Voltage Circuit Protective Devices
264300	Surge Protective Devices

**SECTION 23 0010
GENERAL PROVISIONS – HVAC**

PART 1: GENERAL

1.1 DESCRIPTION

- A. These Mechanical General provisions specified herein apply to all Sections of Division 23.

1.2 WORK INCLUDED

- A. Provide all materials, labor and services as specified in Division 23 and shown on the accompanying drawings.

1.3 RELATED SECTION

- A. Section 23 0100 Operation and Maintenance of HVAC Systems

1.4 DEFINITIONS

- A. Terms: The following definitions of terms supplement those of the General Conditions and are applicable to all Mechanical Sections.
1. Provide: Furnish, install, and connect completely.
 2. Piping: Pipe installed with all required fittings, valves, and accessories, and forming a complete system.
 3. Wiring: Wire or cable installed in raceway with all required boxes, fittings, connectors, and accessories completely installed.
 4. Power Wiring: Wiring that supplies the electrical current that flows through a connected motor or heater.
 5. Exposed: Revealed to view or subject to weather.
 6. Control, interlock and starting circuit wiring: All wiring required by all Mechanical Sections that is not power wiring.
 7. Fittings: All connecting pieces of a system.
- B. Drawings: The Mechanical Drawings are diagrammatic except where otherwise specifically indicated. Refer to Architectural and Structural Drawings for building dimensions.
- C. Materials: Refer to the General Conditions. All material shall be suitable for the service and operating conditions of this Specification.

1.5 ABBREVIATIONS

- A. The following abbreviations are used in this Division of the Specifications:

AABC	Associated Air Balance Council
ABMA	American Boiler Manufacturers Association
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
AMCA	Air Movement Control Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CTI	Cooling Tower Institute
IEEE	Institute of Electrical and Electronics Engineers

ISO	International Organization for Standardization
NEMA	National Electrical Manufacturers Association
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
TEMA	Tubular Exchanger Manufacturers Association
UL	Underwriters Laboratories

1.6 APPLICABLE CODES

- A. The latest amended editions of the codes applicable to the work of the municipality having jurisdiction.
- B. In the absence of any municipal adopted codes, the following shall apply:
 - 1. International Building Code, 2012 Edition, with Georgia Amendments (2014) (2015) (2017) (2018)
 - 2. International Residential Code, 2012 Edition, with Georgia Amendments (2014) (2015)
 - 3. International Fire Code, 2012 Edition, with Georgia Amendments (2014)
 - 4. International Plumbing Code, 2012 Edition, with Georgia Amendments (2014, 2015)
 - 5. International Mechanical Code, 2012 Edition, with Georgia Amendments (2014, 2015)
 - 6. International Fuel Gas Code, 2012 Edition, with Georgia Amendments (2014, 2015)
 - 7. National Electrical Code, 2017 Edition (No Georgia Amendments)
 - 8. International Energy Conservation Code, 2009 Edition, with Georgia Supplements and Amendments (2011, 2012)
 - 9. All City, County, State, Regional, and other ordinances applicable to the work shall apply.

1.7 RELATED WORK

- A. The following work is generally specified in other Divisions of the Specifications, except as specifically otherwise stated in this Division.
 - 1. Electric power wiring.
 - 2. Painting.
 - 3. Installation of access panels in walls and ceiling construction.
 - 4. Installation of starters, contactors, thermal overload switches, and remote push buttons.
 - 5. Curbs, other than pre-fabricated.
 - 6. Flashing and pitch pockets around equipment on roof.
 - 7. Furnishing and installation of motor control center.
 - 8. Foundation drain tile.
 - 9. Catch basin construction.
 - 10. Concrete pump pits.
 - 11. Installation of door grilles.
 - 12. Structural support for heat rejection equipment.
 - 13. Louvers and screens.
 - 14. Cutting and patching of walls, floors, ceilings, roofs, and structure of existing buildings.
 - 15. Subway grating and frame.
 - 16. Demolition.
 - 17. Excavation.
 - 18. Trenching and backfilling.

1.8 SPACE CONDITIONS

- A. All work shall fit the spaces available. Verify all dimensions of the work before commencing fabrication and/or installation.

- B. Minor deviations from the drawings required to conform to space conditions and to provide the required operation, service, or maintenance accessibility shall be made at no additional cost, and subject to approval.
- C. Piping, equipment, or ductwork shall not be installed in electrical equipment rooms. Outside of electrical equipment rooms, do not run piping or ductwork, or locate equipment, with respect to switchboards, panel boards, power panels, motor control centers, or dry-type transformers:
 - 1. Within 42" in front (and rear if free standing) of equipment; or
 - 2. Within 36" of sides of equipment
 - 3. Clearances apply vertically from floor to ceiling structures.
- D. Hydronic piping shall not be installed above any electrical or control panels.

1.9 RECORD DRAWINGS

- A. Upon completion of the Project, the Contractor shall submit one set of contract prints with red marks indicating as-built conditions of all piping, ductwork, and equipment, and incorporating changes made during construction. A record of as-built conditions shall be kept throughout the project and shall be used in the preparation of the final record drawings.
- B. The Contractor shall provide digital images (minimum resolution of 1152 x 864 pixels in JPEG standard image file format) delivered via email, thumb drive, or on CD, of any utilities/piping that are installed underground with a reference drawing indicating which direction each picture is taken. The reference drawing shall dimension the utility/piping from a prominent fixed object.
- C. Repair of refrigerant systems shall include prompt correction of all leaks and replacement of lost oil and refrigerant.

1.10 GUARANTEES

- A. Furnish a written guarantee covering each category of work for a period of one year from date of legal acceptance for the project. Guarantee shall include prompt correction of all leaks.
- B. Guarantee shall be furnished in exact conformity with the requirements of the General Conditions.

1.11 BUILDING UTILITIES

- A. Arrange with appropriate utility agencies for the connection of all utility services and pay all charges in connection therewith.
- B. Where boring under city streets or state highways is required for connection to utilities, contractor shall confirm and follow requirements as outlined by authority responsible for utility systems. All costs for boring shall be paid by the contractor.

1.12 CONTINUITY OF SERVICE

- A. All work shall be scheduled with that of other trades. The following conditions shall apply to all affected work.
 - 1. Before disconnecting any existing systems for changes, the Contractor shall:
 - a. Have all needed materials stored at the job site.

- b. Have assurance that all labor and skilled mechanics needed will be available at the proper time.
 - c. Estimate the time the system will be out of service and inform the Owner in writing.
 - d. Secure approval of the shutdown dates from the Owner in writing before disconnecting the system.
2. The existing cooling tower shall not be removed from operation until the new tower is in place, wired, piped, and ready for final connection to existing piping.
 3. Piping for the existing cooling tower to remain in use shall not be made unusable until the new piping has been installed and ready for final connections to existing piping.
 4. The operation of the cooling systems shall not be interrupted but one time and that period of shutdown shall be kept to a minimum.
 5. All shutdown of air conditioning systems shall be made when the temperature is projected to be below 45°F.
 6. No existing air conditioning system and/or equipment shall be shut down for more than fifteen minutes without the approval of the Owner.
 7. Work shall be so conducted that the water and gas supply and drainage of existing services will not be interrupted when such services are required for normal usage of the occupied portions of the existing building.
 8. Work shall be done at such time and in such manner as to cause minimum inconvenience to the Owner and as approved by him or his representative. No allowance will be made for lack of knowledge of existing conditions.

1.13 EXISTING CONDITIONS

- A. Existing systems and equipment shall remain unchanged except where otherwise specified or shown on the drawings.
- B. Where pipes, ducts, or controls that are to remain in service are disconnected for removal of equipment or because of building alterations, they shall be reconnected to match the existing installation.
- C. The remodeling work to be done in the existing building shall be coordinated with work of other trades. New piping, ducts, or controls shall be run to point of connection to existing piping and tie-ins shall be made in such a manner as to afford minimum inconvenience to building occupants and operation.
- D. All pipe, valves, fittings, etc. that are removed from the existing building shall become the property of the Contractor and shall be removed from the premises. Due allowances shall be made for this material in the bid.
- E. All existing wall-mounted thermostats containing mercury bulbs, shown to be removed, shall be delivered to the nearest Thermostat Recycling (TRC) collection point. Collection points can be found at www.nema.org/trc. Obtain a receipt for the number of thermostats returned and include a copy in the warranty and guarantee portion of the project completion documentation.
- F. Existing work shall be relocated as shown on the drawings.
- G. Existing work shall be removed as shown on the drawings.
- H. Work shall include the removal or extension of and connection to parts of the existing work, and all changes in the existing system to make it conform to changes in the building.
- I. Piping rendered useless by the removal of walls, partitions, fixtures, etc., shall be removed and the outlets at the main plugged behind the finish surfaces.

1.14 OPERATING INSTRUCTIONS

- A. Instructions: Instruct the Owner's representative in operation of the installed systems. The basis of these instructions shall be those written for inclusion in the maintenance and operating instruction data specified herein. Obtain certificates, signed by the Owner's representative, that these instructions have been received.
- B. Notification: Notify the Owner at least five days before commencing operating period for refrigeration and heating equipment, as specified herein, in order that the Owner's representative may be present during that period.

1.15 DOCUMENTATION

- A. Documents to be submitted prior to request for final inspection:
 - 1. Maintenance Manuals per Section 23 0100 Operation and Maintenance of HVAC Systems.
 - 2. Test and Balance Report.
 - 3. Three copies of multi-year warranties bound in a brochure with index listing equipment.
- B. Data to be Delivered at Final Inspection:
 - 1. Record Drawings.
 - 2. Certificate by Owner's representative confirming that operating instructions have been received.

1.16 SUBMITTALS

- A. Procedure: Refer to the GENERAL CONDITIONS and SUPPLEMENTS thereto for submittal procedure of items called for in the Contract Documents.
- B. Submittal data covering the work of this Division will be reviewed only after such items have been reviewed in detail and approved by the Contractor, such approval being indicated by suitable notations or stamp on the data.
- C. **Each submittal shall be clearly marked indicating Specification Section and paragraph for which it is intended. Any deviations, exclusions or substitutions from specified material requirements shall be specifically identified in a summary sheet at the front of the submittal.**
- D. **Where submittal sheets contain multiple products or selections, the specific item being submitted for review shall be clearly indicated with a red arrow (stamped or hand written). "Catalog" submittals (multiple items contained in the submittal, specific items not identified) will be rejected and not reviewed.**
- E. Submit the requested submittals in sufficient quantity to provide two copies in addition to those required by Contractor.
- F. All fan and pump submittals shall include performance curves indicating flow, pressure, efficiency, and power requirements. For pumps, adjacent impeller selections shall be included. For fans, alternate rpm curves shall be included.
- G. Motor Tabulation on all motors furnished, listing the following nameplate data: horsepower, voltage, phase, and full load amps.
- H. Submittal List: See the individual Mechanical Specification Sections for specific submittal requirements.

1.17 SHOP DRAWINGS GENERAL

- A. Shop drawings shall be complete and shall accurately show all items of equipment and material called for. The number of drawings, and the view contained therein, shall be as needed to show the actual and final routing, construction, and final assembly of each system.
- B. All drawings shall be mechanically produced. Free-hand drawings are not acceptable.
- C. All lettering shall be legible without use or aid of magnifying device. Legible free-hand lettering will be acceptable. Lettering shall be minimum 1/8" size.
- D. Date all shop drawings and provide a revision column.
- E. Drawings shall be printed (or plotted) at either 24" high by 36" wide, or the same size as the contract drawings for the same trade, whichever is greater. Each drawing sheet shall be formatted the same as the Contract Documents (i.e., border width, title block, etc.). With the exception of Isometric drawings, all other drawings shall be drawn in two-dimension or at the same scale as the contract drawing of the same area, or as follows, whichever is the larger scale:

<u>Drawing Type</u>	<u>Minimum Scale</u>
Floor Plans	1/8" per foot
Roof Plans	1/8" per foot
Elevations	1/4" per foot
Details	3/4" per foot
Equipment Room Layouts	1/4" per foot
Housekeeping Pad Layouts	1/4" per foot
Isometrics	No scale
Riser Diagrams	1/4" per foot
Equipment Room Pad Layout with Electrical Stub-ups	1/4" per foot
All other plans and elevations	1/2" per foot

- F. Three-dimensional views may be produced and used to provide supplemental information to that which is given on two-dimensional drawings. Three-dimensional drawings shall be drawn from a 30° perspective.
- G. Each individual shop drawing sheet shall contain a single format (two-dimensional or three-dimensional).
- H. In addition to information shown on the Contract Documents, provide all additional data and notations needed to show conformance with Contract Documents. (i.e., air flow and volume from /to air devices).
- I. For all drawings drawn two-dimension, all characteristics of the Contractor's equipment, systems and components shall be drawn to scale to designate their size. Use of dimensions alone to designate width, height, length, or depth is not acceptable. Drawings will not require that the reader "scale" them to determine sizes or location.
- J. In the event either the project as a whole, or the specific area covered by a particular shop drawing, does not contain columns, floors and/or walls to which reference can be made in the location of items, alternate points of reference, as approved by the Architect, may be used.
- K. Shop Drawings drawn at the same scale as the Contract Drawings shall incorporate the same areas, be arranged and be "broken" along the same lines as the Contract Drawings.

- L. Duct and piping system which have following maximum width on one side shall be drawn in the following manner:

Drawing Scale	Object Dimension	Object Appearance Style
1. 1/8" per ft.	Greater than 8"	Double-line
2. 1/8" per ft.	Less than 8"	Single-line
3. 1/4" per ft.	Greater than 4"	Double-line
4. 1/4" per ft.	Less than 4"	Single-line
5. 1/2" per ft.	Greater than 2-1/2"	Double-line
6. 1/2" per ft.	Less than 2-1/2"	Single-line
7. 3/4" per ft. & larger	Greater than 2-1/2"	Double-line
8. 3/4" per ft. & larger	Less than 2-1/2"	Single-line
9. Flexible duct to diffusers		Single-line

- M. Coordinate with all other trades that might impact installation of other systems, equipment or components.
- N. Each Shop Drawing shall contain a title block that shall be the same size, layout, and location, and have the same lettering size, as the Contract Drawings. Each drawing shall bear its own unique and descriptive designation. Adjacent to the title block shall be a space served for revision dates and identification.
- O. Where adjacent areas of the building are continued on separate drawings, provide a "match-line" at the edge of the drawing area with an identifier directing the reader to the appropriate companion drawing.
- P. Each plan view drawing shall contain a "key plan" of the entire building, or a major portion of the building, to allow for the quick identification of the work area covered by the specific drawing and the orientation of the building (or area) as a whole. The key plan shall be proportionally accurate but not to exceed 4" x 4" in size.
- Q. The following minimum information shall be included on each plan view drawing; ceiling, soffits, ceiling grid, light fixtures, partitions, room name and number, columns and other structural members, doors and/or door swings.
- R. Each drawing shall be revised to keep current with all modifications and revisions. Each modification shall be noted in the margin of each affected drawing. Notes shall consist of a unique modification number, date and brief notation on the reason for being made.

1.18 DUCTWORK SHOP DRAWINGS

- A. Background information shall be redrawn scaled versions of the Architectural Floor or Reflected Ceiling Plans of the Contract Drawings and shall show all partitions, openings, and structural features. Drawings from the Contract Documents shall not be copied for use as backgrounds nor will reproducible drawings be made available from the Architect for this purpose.
- B. Show fitting joints, fittings, equipment, required maintenance, removal and safe working clearances, elevations, location and sizes of access panels, net sizes (size of system less insulation), dimension from finished floor and/or overhead structure, horizontal dimension from centerline of columns, direction of flow, changes in size, changes in external covering, system material, construction classification, system name, internal liner, unique situations, equipment designation.

- C. Show floor plan location of all space control and sensing devices (thermostats, humidistats, etc.) complete with the designation of the piece of equipment or component which device controls. Lines drawn between the sensing device to the controlled equipment or component, to designate their interaction, are not acceptable.
- D. Sheet metal work shall be drawn using symbols and designations in accordance with the latest edition of "SMACNA Duct Construction Standards - Metal and Flexible".

1.19 HVAC PIPING SHOP DRAWINGS

- A. Background shall be the Ductwork Shop Drawings called for elsewhere in this Section except that notes and details pertinent to only ductwork may be omitted.
- B. Show flanges, fittings, equipment, locations and sizes of access panels, required maintenance, removal and safe working clearances, elevations, net size (size of system less thermal or acoustical coverings), dimension from finished floor and/or overhead structure, horizontal dimension from centerline of columns, grade, percent of slope and/or rate of change, direction of flow, changes in size, changes in external covering, system material, construction classification, system name or symbol, unique situations, equipment designation.
- C. Show floor plan location of all space control and sensing devices (thermostats, humidistats) complete with the designation of the piece of equipment or component which device controls. Lines drawn between the sensing device to the controlled equipment or component, to designate their interaction are not acceptable.
- D. Piping shall be drawn utilizing the symbols and designations as shown on the Contract Documents.
- E. Each piece of equipment or manufactured product shall bear the same designation as indicated on the Contract Documents.

1.20 EQUIPMENT ROOM SHOP DRAWINGS

- A. Background shall be redrawn scaled versions of the Architectural Floor Plan showing all partitions, openings, and structural features.
- B. Show actual size and location of equipment in both plan and vertical section.
- C. Equipment and equipment pads shall be drawn to scale and dimensioned. Dimensions shall conform to actual manufacturer's dimensions for product used.
- D. Show dimensions of equipment placing relative to partitions, columns, beams, and underside of structural deck.
- E. Show and dimension all service clearances, access door swings, vertical clearances.
- F. Show all piping, breaching, pumps, and equipment to provide full information for coordination.
- G. Show electrical panels to scale, including control panels and disconnect switches.

END OF SECTION 23 0010

**SECTION 23 0100
OPERATION AND MAINTENANCE OF HVAC SYSTEMS**

PART 1: GENERAL

1.1 MAINTENANCE AND OPERATING MANUALS

- A. Provide manual in number of copies indicated under Section 23 0010 General Provisions - HVAC.
- B. Material submitted in the manuals shall represent the equipment manufacturer, model, and type installed on the project.

PART 2: PRODUCTS

2.1 MAINTENANCE AND OPERATING MANUALS

- A. Maintenance and Operating Manuals shall consist of the following as a minimum:
 - 1. Hardback three-ring binders with project name and Owner's name on cover.
 - 2. Typed index listing name, address, and phone number of the General Contractor, HVAC Subcontractor, Insulation Subcontractor, Sheetmetal Subcontractor, and Controls Subcontractor, and all major equipment suppliers.
 - 3. Typed table of contents, listing each Section, title, and number.
 - 4. All Sections shall be tabbed with plastic tabs listing Section numbers.
 - 5. Each item of equipment requiring maintenance and operation data as noted in each specification section shall be provided with an index listing the types of equipment installed. Submittal data shall be included to the extent necessary to identify equipment, including summary sheet, such as model, size, air or water flow, pressure developed, speed, and motor size. Instructions shall include type and suggested frequency of maintenance, oiling, cleaning, disassembly and reassembly directions, and wiring diagrams.
 - 6. One section shall include a complete set of record control drawings, bound in a plastic insert, full size, complete with a written sequence of operation for all control systems.
 - 7. Letters, where factory startup or checking has been required, certifying completion of performance.

PART 3: EXECUTION

3.1 MAINTENANCE AND OPERATING MANUALS

- A. All maintenance and operating manuals shall be complete and ready to turn over to Owner's representative at final inspection.
- B. Incomplete manuals will be returned to the Contractor for complete resubmission. Loose-leaf submittal of material at various stages of completion will not be acceptable.

END OF SECTION 23 0100

**SECTION 23 0500
COMMON WORK RESULTS FOR HVAC**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This Section of specifications deals with materials and methods pertaining to all work specified under Division 23.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions Mechanical
- B. Section 23 0523 HVAC Valves and Strainers

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide submittal data showing starter dimensions, weight, electrical requirements, and service access requirements.
- C. Provide submittal data showing motor horsepower, electrical requirements, and efficiency.
- D. Provide submittal data showing firestop systems, including details for penetrations and instructions for installation
- E. Provide manufacturer's instructions, indicate installation and support requirements.

1.4 JOB CONDITIONS

- A. Install all apparatus to maintain maximum headroom and clearances consistent with requirements of the drawings and specifications.
- B. All equipment requiring service shall be installed to permit access for servicing without damage to building structure or finishes.

PART 2: PRODUCTS

2.1 DRIVES

- A. Belt drives shall be sized for 150% of motor horsepower. Motor pulleys shall be cast iron, adjustable pitch for 15 hp and below, fixed pitch above 15 hp.
- B. Drive speeds scheduled are estimated; provide fixed or adjustable pitch sheaves necessary to deliver scheduled air quantities based on actual static pressure in the system.
- C. Multiple belt drives shall be used on motors 5 horsepower and larger.

2.2 DRIVE GUARDS

- A. Drive guards shall be provided for all driven equipment. Drive guards shall be designed to meet OSHA requirements.
- B. Belt drive guards shall be constructed of galvanized expanded metal reinforced with galvanized angle steel frame. Guard shall be welded or formed of one piece of material.

- C. Provide minimum 3" diameter access plate at motor shaft and driven apparatus shaft for belt guards. Access plates shall be attached with aircraft type locking wing nuts.
- D. Drive guards shall be rigidly bolted to the frame of the equipment. All drive guards shall be removable.

2.3 MOTORS

- A. Provide motors for all equipment required by the Mechanical Sections unless otherwise specified. Motors shall operate using Electrical characteristics shown on the Drawings and as specified. Multiple units of the same manufacturer's equipment shall be furnished with motors by one manufacturer. Motors shall be Century, Louis-Allis, Baldor-Reliance, General Electric, Westinghouse, Marathon, or US Motors, except where furnished as part of packaged equipment.
- B. Standards: Except where otherwise specified, motors shall be manufactured according to NEMA Standards. They shall be NEMA Design B, Continuous Duty, 1.15 service factor, Insulation Class B or F, 40°C. ambient and 40°C. rise. Hermetic motors shall be manufactured according to AHRI Standards.
- C. Efficiency: All design A & B squirrel-cage, foot-mounted, single-speed T-frame induction motors 1 hp and larger having synchronous speeds of 3600, 1800, and 1200, rpm shall have a nominal full-load motor efficiency no less than that shown below or shall be classified under NEMA standard as "ENERGY EFFICIENT": Please refer to the chart entitled "Minimal Nominal Full-Load Efficiencies (%)" at the end of this section.
- D. Sizes:
 - 1. Motors with standard NEMA Electrical characteristics shall be selected for the design brake horsepower without overload current at rated voltage. Motor horsepower rating shall not exceed 125% of the calculated maximum load being served. If a standard rated motor is not available within the range, the next larger standard motor size shall be used.
 - 2. Motors with special electrical characteristics, such as hermetic refrigeration motors, shall be selected to product the brake horsepower required for the specified load without overload current at rated voltage.
 - 3. Motors used with variable speed adjustable frequency controllers shall be suitable for inverter duty use, constructed in compliance with NEMA Standard MG 1, latest edition, and selected to operate with the control characteristics and amperage limitations of the specific inverter selected. All motors associated with variable frequency drives shall be furnished with a factory-installed shaft grounding ring (SGR) of conductive micro-fibers to redirect shaft currents from shaft to frame. SGR shall be maintenance-free, brushless, split-ring or complete-ring configuration directly attached with mechanical fasteners. Attachment with adhesives in lieu of mechanical fasteners shall not be an acceptable substitution. SGR shall be by Aegis or equivalent.
 - 4. Motors designated as two-speed shall be two speed/two winding type.
- E. Enclosures: Motor enclosures shall be open drip-proof, except where otherwise specified. Motors for equipment installed where subject to weather shall be fan cooled, totally enclosed weatherproof type, unless fully protected by a waterproof housing.
- F. Nameplates: All motors shall have a nameplate showing the specified nominal system voltage as nameplate rated system voltage. Each motor shall be guaranteed to operate satisfactorily at the specified nominal system voltage, plus or minus 10%.

2.4 CONTACTORS

- A. Contactors shall be magnetic designed for resistance heating and tested for 100,000 cycles. Contacts shall be silver alloy. Enclosure shall meet the requirements of UL 508 with NEMA Type 1 indoors, and Type 3R outdoors. Provide one set of auxiliary contacts and control transformer with fused, grounded secondary. Holding coil voltage shall not exceed 120 volts.
- B. Manufacturers: Clark Controller, Arrow-Hart, Cutler-Hammer, Allen-Bradley, Square D, or Siemens (Furnas).

2.5 STARTERS

- A. Manufacturers: Cutler-Hammer, Square D, Allen-Bradley, Siemens (Furnas), or General Electric.
- B. Except as otherwise specified, furnish starter, providing thermal overload protection, for each motor specified herein. Overload elements shall be sized to protect motors. Overload protection shall be provided in each motor leg. Auxiliary contacts, NEMA A600 rated, shall be provided for wiring specified under "Controls". Contacts shall be Form C type, open on alarm. Provide two spare normally open and two spare normally closed contacts. Starters shall be constructed and rated for 50,000 amps withstand rating.
- C. Unless noted otherwise, all automatically controlled motor starters shall be furnished with "hand-off-auto" selector switch, reset button and LED pilot light in cover.
- D. Combination starters, except those specifically noted to have a fusible disconnect switch, shall also contain a circuit breaker type motor circuit protector with adjustable instantaneous magnetic trip and without thermal trip unit, UL listed for motor branch circuit protection. The frame size, trip rating and setting shall be selected based on the horsepower of the motor as indicated on the Drawings. Disconnect or breaker handle shall have padlocking provisions.
- E. All three-phase starters serving motors over 208 volts shall have control transformer with fused 120 volt secondary. Holding coils shall be 120 volt. Provide overload protection for each of three phases. Enclosures shall be NEMA Type 1 for indoor locations and NEMA Type 3R for outdoor locations, unless otherwise noted.
- F. All manual single-phase starters shall be furnished with LED pilot light, NEMA Type 1 enclosure indoors, and NEMA Type 3R outdoors. Starters located in finished spaces shall be furnished with flush mounting enclosures.
- G. Provide engraved plastic nameplate for each starter with description of equipment served. Nameplate shall state source of circuit, load served, circuit number if used, voltage and phase.
- H. Provide two-speed two-winding motor starters where two-speed motors are required.

2.6 SUPPORTS AND HANGERS

- A. Individual horizontal piping shall be supported as follows:
 - 1. Steel and cast-iron piping with painted clevis hangers, except steam and steam condensate 4" and larger shall be on roller hangers.
 - 2. Hangers in contact with copper piping shall be copper-plated swivel-ring type.
 - 3. Hangers around insulated copper piping shall be galvanized steel swivel-ring type.
 - 4. Copper piping exposed adjacent to structure shall be secured with copper-plated pipe clamp.
 - 5. All attachments in contact with copper piping shall be copper, copper plated, or plastic coated.

6. Horizontal, parallel, and adjacent piping shall be supported by gang hangers utilizing PVC-coated channel and PVC-coated standard pipe clamps or approved equivalent.
- B. Concealed vertical piping shall be supported as follows:
 1. Steel and cast iron piping with painted riser clamps.
 2. Copper piping with copper-plated riser clamps.
- C. Exposed vertical piping shall be supported by attachment to wall at midpoint with offset pipe clamps. Clamp for uninsulated copper piping shall be copper plated or plastic coated.
- D. Pipe in Chases: Piping in pipe chases shall be secured to building structure using attachments hereinbefore specified. Hangers for water piping within plumbing chases shall be supported with rods bolted to pipe clamps which shall be affixed to cast iron pipe. Piping may be supported from the more rigid cast iron pipe with the use of plastic brackets designed for that purpose.
- E. Hangers and pipe attachments, except where otherwise specified shall be Elcen, B-Line, or Grinnell.

2.7 STRUCTURAL ATTACHMENTS

- A. Concrete Fasteners/Anchors
 1. Fasteners shall be self-drilling type, Bull Dog, Phillips "Red Head", or Diamond "Blue-Cut".
 2. Fasteners shall be used in solid masonry walls and shall be used in solid concrete walls.
- B. Toggle Bolts with not less than 1/4" diameter bolts shall be used in hollow-type wall construction.
- C. Clamps of configuration compatible with beams and steel members shall be used in steel construction. Clamps shall be Grinnell, Michigan Hanger, Elcen, or B-Line.
- D. Hanger rods shall be selected to safely carry the load to be supported and shall not be less than the diameter listed by the hanger manufacturers for the specific size hanger used.

2.8 FOUNDATIONS

- A. Provide reinforced concrete foundations for all equipment located on floors, 4" high unless noted otherwise.
- B. Concrete shall be 1:2:4 mix with neatly beveled edges and all surfaces rubbed smooth prior to mounting equipment. Foundations shall be reinforced with No. 3 bars a maximum of 12" o.c. each way and held in place with dowel rods at each corner anchored in the slab. Dowel rods shall not penetrate the slab waterproofing.

2.9 FIRESTOP SEALANT

- A. Firestop sealant shall be a synthetic elastomer caulk, strip, or sheet designed for use as a one-part fire, smoke, and gas sealant. Material shall be intumescent and capable of being installed with caulk gun, shears, and putty knife. Material shall be UL classified and Factory Mutual approved for sealing in floors, walls, or partitions to three-hour rating per ASTM E-814.
- B. Fire barrier material shall be 3M Fire Barrier Sheet, Strip, and Caulk.

2.10 ASBESTOS

- A. All materials used in this work shall be asbestos free.

PART 3: EXECUTION

3.1 INSTALLATION

- A. All work shall be installed plumb and square unless clearly indicated otherwise. Installation shall be performed by competent persons, trained in their respective skills.
- B. Furnish and install equipment complete, including connections, services and adjustments for systems to operate safely and in compliance with requirements of the contract.
- C. Install each item in full compliance with current recommendations of the manufacturer. Equipment manufacturer or his authorized representative shall furnish services and/or supervision necessary to ensure compliance with this provision. Conflict between manufacturer's recommendation and other contract requirements shall be resolved before installation.
- D. Requirements of the several acceptable manufacturers for each specified item of equipment may vary as to installation details, location and number of connections, dimensions and weight. Provide all drawings, services, material, and labor necessary for the installation and proper functioning of the equipment furnished.

3.2 PROTECTION OF MATERIALS AND EQUIPMENT

- A. Take precautions to protect all materials and equipment from damage during the construction process.
- B. Do not store materials and equipment outdoors subject to weather without complete weather protection.
- C. Do not install materials or equipment in a partially constructed structure exposed to weather, unless all material and equipment is continuously protected from damage by weather or the construction process.
- D. Material and equipment damaged by improper protection during construction is subject to replacement based on the judgment of the Engineer at no cost to the Owner.

3.3 CUTTING AND REPAIRING

- A. Cut and repair all walls, floors, and ceilings necessary for the installation of the mechanical work, but no cutting of work of other trades will be permitted without the consent of the Architect or his representative.
- B. All cutting and repairing of walls, floors, and ceilings shall be subject to the supervision and approval of the Contractor.

3.4 CLEANING AND FINAL CLEAN-UP

- A. Keep the premises free of waste, debris, and surplus materials.
- B. After equipment has been installed, remove all extraneous materials, rust and stains; blow, vacuum or flush all foreign matter from all equipment.
- C. Identification plates on equipment shall be free of paint and shall be polished.

3.5 DRIVES AND GUARDS

- A. All belt drive alignments shall be properly checked and set prior to starting machinery.
- B. Adjust drives to deliver air quantities scheduled at actual static pressures. Change sheaves to meet actual conditions, if required.
- C. Provide one set of spare belts to be turned over to the Owner at the completion of the work for each air handling unit drive.
- D. All equipment guards shall be OSHA compliant and installed prior to operation of equipment.

3.6 MOTOR VOLTAGES

- A. All motor voltages shall be checked with the electrical drawings prior to preparation of submittals or ordering of equipment.

3.7 MOTOR STARTER OVERLOADS

- A. Motor overload heaters shall be sized and installed to protect the actual motor furnished.

3.8 PIPING SUPPORTS AND ANCHORS

- A. Waste, drain, and relief valve discharge piping shall be securely anchored to structure, equipment or concrete base. Piping shall be located with two inches clear above the floor.
- B. Combination riser clamps may be used where more than one pipe passes through floors.
- C. Riser clamps for support of risers shall span penetration of slot or sleeve in floor. In exposed location, use short span clamps.
- D. Hang all piping so that equipment flanges and connections bear none of weight of piping. At pump suction and discharges, piping shall be supported free of pump casing through the use of base elbows.
- E. Horizontal supports shall be spaced as follows:
 - 1. Steel piping at not more than 10' intervals.
 - 2. Cast iron piping at 5' intervals, except supports shall be placed at intervals equal to the pipe length but not to exceed 10'. Also, no hub pipe over 3" size shall be supported at each change from horizontal to vertical or vertical to horizontal direction.
 - 3. Copper piping 1" and smaller at 8' intervals; larger than 1" at 10' intervals.
 - 4. PVC piping at not more than 4' intervals.
 - 5. PVC piping 1½" and under shall be supported at 4' intervals maximum.
- F. Vertical supports shall be spaced as follows:
 - 1. Steel piping at every other story height.
 - 2. Copper piping larger than 1" at every other story height; 1" and smaller at every story height.

3.9 HANGER SIZES

- A. Hangers shall be sized to fit the pipe except for the insulated piping, in which case hangers shall be of size for pipe and insulation to pass through.
- B. See Section 23 0700 HVAC Insulation for pipe shields.

3.10 FIRESTOP SEALING FLOOR AND WALL PENETRATIONS

- A. Where ductwork, piping, control tubing, and conduit penetrate fire- or smoke-rated walls and floors, the penetration shall be sealed with fire barrier herein specified.
- B. Fire barrier shall be installed in strict accordance with manufacturer's printed instructions. Material shall be installed with sufficient depth to maintain a fire endurance rating equivalent to that of the adjacent wall or floor.

3.11 REFRIGERATION SYSTEMS

- A. Any work required on new or existing refrigeration systems shall involve the use of a refrigeration recovery/recycling unit. All refrigerants shall be stored and reused in the system where the refrigerant condition allows. Intentional release of refrigerant is prohibited and will not be allowed.

3.12 LUBRICATION

- A. All equipment installed under this division shall be properly lubricated in accordance with the manufacturer's instructions and recommendations before it is operated during the installation period and shall be checked again before final acceptance.

END OF SECTION 23 0500

**SECTION 23 0514
VARIABLE FREQUENCY DRIVES**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This Section specifies the requirements for the adjustable frequency variable torque voltage source drive controller (VFD).

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions - HVAC
- B. Section 23 0100 Operation and Maintenance of HVAC Systems
- C. Section 23 0500 Common Work Results for HVAC
- D. Section 23 0923 Building Automation System

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide VFD shop drawings, include dimensioned drawings, system wiring diagrams, termination details, data sheets describing all major components and electrical characteristics plainly demonstrating compliance with each specification requirement.
- C. Provide data for each VFD consisting of: Wiring length from VFD to motor, load side accessories, and minimum recommended conductor size.
- D. Provide copy of warranty.
- E. Provide manufacturer's instruction; indicate installation and support requirements.
- F. Provide operation and maintenance procedures; include detailed drawings, parts lists, physical component for layout drawings, and control diagrams with wire numbers indicated for controller. Provide manufacturers published recommended procedures for preventative maintenance, repair and normal operation of the controller all components.
- G. Copy of confirmation from manufacturer certifying burn-in of equipment and factory testing.
- H. Copy of manufacturer's dated warranty.

1.4 MOTOR PROTECTION

- A. Prior to releasing any pricing data on the VFD(s) required for this project, the VFD vendor shall verify the approximate wiring length from the VFD to the associated motor. Based on the specific VFD manufacturer's published recommendations, the VFD vendor shall provide any additional accessories (output reactor, output filter, etc.) required to insure reliable, long-term operation of the driven motor. The VFD vendor shall also advise the purchasing party if the VFD manufacturer's published recommendations require larger electrical conductors than are currently shown on the construction documents.

1.5 FACTORY TESTING

- A. The VFD shall be burned in a minimum of 24 hours prior to leaving the factory. During the burn-in period, the VFD shall be continuously cycled between no load and full load. The Architect shall be given 72 hours advanced notice in writing of factory testing and the Architect and Owner shall be permitted to witness such testing.
- B. During the factory testing, all normal operating modes, indications, controls, failure modes, and alarms shall be tested and demonstrated.

1.6 WARRANTY

- A. The VFD shall be warranted by the manufacturer for a period of 30 months from the date of start-up by factory-authorized technician. The warranty shall state that all warranty repair will be performed onsite at no cost to the Owner.

1.7 FACTORY START-UP SERVICE

- A. The VFD manufacturer shall provide onsite start-up service performed by a factory-trained and authorized technician. The technician shall:
 - 1. verify correct installation,
 - 2. start up the drive,
 - 3. check for proper operation,
 - 4. verify wiring to and driven motor comply with published recommendations,
 - 5. demonstrate all operational and failure modes to the Owner,
 - 6. assist in interface of the drive with the temperature control system, and
 - 7. provide operational training to the Owner's personnel.
- B. The technician shall remain on site at no extra cost to the Owner until the Engineer has acknowledged that all the obligations listed above have been performed.

1.8 DIVISION OF WORK

- A. The VFD shall receive input from the Automatic Temperature Control System (ATC) specified under another Division. Provide control input interface compatible with input from ATC.

1.9 SPARES

- A. Provide two (2) replacement fuses for each fuse used in the drive.
- B. Include letter from manufacturer's representative, indicating that spare parts are available in 48 hours.

PART 2: PRODUCTS

2.1 GENERAL CHARACTERISTICS

- A. The entire variable speed drive assembly shall be listed by Underwriters Laboratories, Standard UL 508. The variable speed drive shall convert three phase 60hz power to adjustable frequency and voltage, three phase, for stepless motor speed control from 10% to 100% of the motors 60hz speed.
- B. The VFD shall include in one cabinet a converter, an inverter and a manual transfer bypass switch. Input line reactors of 3% impedance or 3% DC link reactor shall be provided for each variable speed drive. Dimensions shall not exceed those shown on the Drawings.

- C. Full-wave diode bridge rectifiers shall be used on units 25 HP and smaller. Input line noise shall be limited to a voltage distortion factory and line notch depth as defined in IEEE Standard 519-1992, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. The VFD shall comply with the applicable requirements of ANSI, IEEE and NEC. The drive shall be UL/ETL listed and conform to UL 508.
- D. The inverter section of the drive shall invert the variable DC voltage into a waveform.
- E. The continuous output rating shall be 110% of the nameplate full load rating of the induction motor used in fan service as specified under other Divisions.

2.2 REQUIRED FEATURES

- A. NEMA 1 wall-mounted enclosure with all operator controls on the front panel. Rear access shall not be required for installation, operation, or maintenance. Controller shall be rated for 65,000 amps RMS symmetrical, unless otherwise noted.
- B. Hand/Off/Auto Selector.
- C. Manual/Auto selector to select local or remote speed control.
- D. Disconnects for input and bypass power terminals with fuses installed. In lieu of disconnects, equipment may be provided with interlocked input, bypass, and output contactors.
- E. Manual speed control – locking ten turn potentiometer or Up/Down push-button with infinite speeds.
- F. Indicators for input available, output from drive on, drive fault.
- G. Digital meter indicating percent speed and percent load or RMS amps output.
- H. Two (2) drive running aux contacts for Owner use.
- I. Two (2) drive fault aux contacts for Owner use.
- J. Protection against damage from line transients in accordance with IEEE standards.
- K. Protection from damage due to input under or overvoltage and phase loss. Protection from damage due to output current overload or overcurrent.
- L. Protection from damage due to overtemperature within the drive enclosure.
- M. Protection from damage due to DC bus overvoltage.
- N. DC bus discharge circuit for maintenance.
- O. No sensitivity to input phase sequence.
- P. Input signal isolation circuit to allow use of floating signal with no ground reference.
- Q. Compatibility with input signal of type selected by automatic controls vendor. Provide RS 485 communications interface capable of two-way communications.
- R. Three phase motor overcurrent protection.
- S. Analog output signal for remote indication of motor speed, either 0-10v DC grounded or 4-20mA ungrounded.

- T. Permanent machine-made wire number on each end of each control conductor. Permanent terminal number for each terminal strip.

2.3 ADJUSTMENTS

- A. Maximum speed: 50 to 100% of base speed.
- B. Minimum speed: 0 to 50% of base speed.
- C. Acceleration time: 3 to 120 seconds.
- D. Deceleration time: 3 to 120 seconds.
- E. Current limit: 0 to 110%.

2.4 SERVICE CONDITIONS

- A. 0 to 40°C ambient.
- B. 0 to 95% relative humidity.
- C. Input line voltage variation +/- 10%.

2.5 ACCEPTABLE

- A. ABB.
- B. Allen-Bradley.
- C. Danfoss.
- D. Square D.

PART 3: EXECUTION

3.1 GENERAL

- A. Contractor shall verify that all motors driven by a VFD shall be inverter duty.
- B. Install drives as noted on the plans.
- C. Receive and install the equipment in accordance with the manufacturer's recommendations and instructions. Manufacturer's representative shall start up and place in service, after all adjustments, each variable speed drive. Submit report of final settings for each control point.
- D. Protect the equipment from moisture and contamination during installation.
- E. Tighten all bus joints and connections to manufacturers recommended torque settings prior to energization.
- F. Lace up all wiring using nylon ties.

END OF SECTION 23 0514

**SECTION 23 0520
PRESSURE GAUGES AND VALVES**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the pressure gauge and gauge valve requirements.

1.2 RELATED SECTION

- A. Section 23 2113 Hydronic Piping

1.3 QUALITY ASSURANCE

- A. Gauges shall be manufactured by Ashcroft, Marsh, Moeller, Terice, or Weksler.

PART 2: PRODUCTS

2.1 GAUGES

- A. Gauges shall be ANSI Grade A dial, indicating type, with 4½" dial and stainless steel case, Plexiglas cover and ring. Bearings shall be bronze.
- B. Accuracy shall be within 1% of full scale range.
- C. Pressure ranges of gauges shall be as follows:
- | | |
|-----------------------------|---------------------|
| Unless otherwise specified: | 0-160 psig |
| Pump suction: | 30" vacuum-160 psig |
| Pump discharge: | 0 to 160-300 psig |
| Domestic water supply: | 0-160 psig |
| Top of standpipes: | 0-160 psig |
- D. Needle valves shall be made of brass with Teflon packing.
- E. Gauge cocks shall be polished brass 200 psi rated cocks with lever handle.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Gauges shall be located and installed so as to be conveniently read from the floor.
- B. Gauges shall be installed upright in a vertical plane when not more than seven feet (7') above the floor.
- C. Provide a gauge cock at each pressure gauge installation.
- D. Install other gauge cocks and needle valves where shown on the plans.

END OF SECTION 23 0520

**SECTION 23 0521
TEMPERATURE GAUGES AND TEST WELLS**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the thermometer and thermometer well requirements.

1.2 RELATED SECTION

- A. Section 23 2113 Hydronic Piping

1.3 QUALITY ASSURANCE

- A. Manufacturers: Thermometers shall be by Ashcroft, Marsh, Moeller, Trerice, or Weksler. Test wells shall be by same manufacturer.

PART 2: PRODUCTS

2.1 THERMOMETERS

- A. Thermometers shall be industrial type with 9" aluminum case, every angle adjustment mount, plexiglass cover, 6" stem, and separable brass socket with 2½" lagging extension.

- B. Temperature range of thermometers shall be as follows:

Air Ducts:	30°-130°F.
Chilled Water Piping:	30°-130°F.
Cooling Tower Water Piping:	30°-130°F.
Tempered Water Piping	30°-130°F.
Hot Water Piping:	30°-300°F.

- C. Accuracy within 1% of full scale range.

2.2 TEST WELLS

- A. Test wells shall be brass with brass plug and chain. Wells shall have 2½" lagging extension.

2.3 TEST PLUGS

- A. Test plugs shall be solid brass temperature and pressure test station, ¼" MPT size, standard length, Nordel valve core, manufactured by Peterson Equipment Company Inc.
- B. Furnish a test kit consisting of 0-100 psi pressure gauge, gauge adapter, 25°F-125°F pocket thermometer, and protective carrying case.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Install thermometers in wells where shown on the plans. Thermometers shall be located and installed to be conveniently read from the floor.
- B. Wells shall be installed vertically or inclined and filled with light oil.

- C. Test plugs shall not be covered by insulation.
- D. Obtain receipt from Owner's representative for test plug kit.

END OF SECTION 23 0521

**SECTION 23 0523
HVAC VALVES AND STRAINERS**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the valves and strainers common to the heating and air conditioning piping systems of Division 23.

1.2 RELATED SECTIONS

- A. Section 23 0500 Common Work Results for HVAC
- B. Section 23 2000 Pipe, Fittings, and Accessories
- C. Section 23 2113 Hydronic Piping

1.3 QUALITY ASSURANCE

- A. All gate, globe, and check valves provided under Mechanical Sections shall be of the same domestic manufacturer, except as otherwise specified.
- B. All other valves of a given type shall be by the same domestic manufacturer.
- C. All valves shall have asbestos-free packing and gaskets.
- D. All brass alloys used in valves shall contain a maximum of 15% zinc.
- E. Valves 2" and under shall be 125 lb class bronze body threaded, rising stem, union bonnet, solid wedge, malleable iron handwheel meeting MSS SP-80.
- F. Valves 2½" and over shall be 125 lb class ASTM A-126 class B iron body, flanged, OS&Y, solid wedge with T-head connection to shaft, bronze trimmed, bolted bonnet, meeting MSS SP-70.
- G. Valves shall be Milwaukee, Nibco, or Stockham/Crane.

1.4 GLOBE VALVES

- A. Valves 2" and smaller shall be 125 lb class ASTM B-62 bronze body, threaded, union bonnet, malleable iron handwheel, composition or Teflon disc for selected service, meeting MSS SP-80.
- B. Valves 2½" and larger shall be 125 lb class ASTM A-126 class B iron body, flanged, gland packed, bolted bonnet, solid disc, and 200 psi non-shock WOG rated meeting MSS SP-85.
- C. Seats and discs shall be selected for steam or water service as required.
- D. Valves shall be Milwaukee, Nibco, or Stockham/Crane.

1.5 CHECK VALVES IN HORIZONTAL PIPE

- A. Valves 2" and under shall be 125 lb class bronze body, threaded, swing type, with full flow area and renewable composition or Teflon disc stainless hinge pin, meeting MSS SP-80.
- B. Valves 2½" and over shall be 125 lb class ASTM A-126 class B cast iron body, flanged, bolted cap, with bronze trim and renewable composition disc meeting MSS SP-71, Type 1.

- C. Seats shall be selected for steam or water service, as required.
- D. Valves shall be Milwaukee, Nibco, or Stockham/Crane.

1.6 CHECK VALVES IN VERTICAL PIPE

- A. Valves 2" and under shall be bronze construction, silent spring type, screwed with stainless steel spring and resilient seat. Valves shall be rated for 200 psi non-shock WOG.
- B. Valves 2½" and over shall be 125 lb class silent cast iron body lug type, flat face, bronze trimmed, with stainless steel spring and resilient seat.
- C. Seats shall be selected for steam or water service as required.
- D. Vertical check valves shall be Muessco/Mueller, Hammond, Milwaukee, or Nibco.

1.7 BALL VALVES

- A. Ball valves 2" and under shall be bronze body, threaded or solder, full port, blowout proof stem, solid stainless or chromed ball, 2" extended handles of non-thermal conductive material to accommodate pipe insulation, memory stop, rated for 600 psi non-shock WOG, and meeting MSS SP-110.
- B. Ball valves shall be Apollo, Hammond, Nibco, or Watts.

1.8 BUTTERFLY VALVES

- A. Butterfly valves 2½" and larger shall be 150 lb class meeting MSS-SP-67 lugged type with ASTM A-126 class B cast iron or ductile iron body, extended neck, lever type, infinite position memory stop handle, stainless steel shaft, bronze or ductile iron disc, stainless steel or bronze shaft bushings and rigid EPDM (BUNA-N) seat designed for service at 200°F minimum.
- B. Valves 6" and larger shall be furnished with weatherproof ASTM A-126 class B iron body worm gear operator and 6" minimum diameter malleable iron rim handwheel.
- C. All valves shall be factory tested and guaranteed bubble tight at 150 psi differential.
- D. Valves shall be rated for dead end service with downstream flange removed.
- E. Butterfly valves shall be Bray, Center Line, Grinnell, Hammond, Keystone, Milwaukee, or Watts.

1.9 RELIEF VALVES

- A. Relief valves for water systems shall be full size minimum, ASME rated for 250 psi and stamped. Valves 2" and under shall be all bronze construction. Pressure settings shall be as specified or shown on the plans.
- B. Valves shall be Kunkle, Spirax Sarco, or Watts.

1.10 PRESSURE REDUCING VALVES

- A. Pressure reducing valves shall be 125 lb class all bronze type with integral strainer. Valve capacity shall be not less than 15 GPM at 20 psi differential pressure.
- B. Water valves shall be Armstrong, Bell & Gossett, Taco, Thrush, or Watts.

1.11 STRAINERS

- A. Strainers 2" and smaller shall be 125 lb class iron or bronze body, threaded, 'Y' type complete with screwed cap and basket.
- B. Strainers 2½" and larger shall be 125 lb class iron body, flanged, bolted cover and tapped outlet.
- C. Strainer baskets shall be as follows:

<u>Service</u>	<u>Material</u>	<u>Perforation</u>	<u>Open Area</u>
Hot water, chilled water, tempered water	Brass	1/10"	35%
Condenser water	Brass	5/32"	60%
Steam	Monel	3/64"	25%

- D. Strainers shall be Crane, Hoffman, Keckley, Mueller, or Watts.

PART 2: EXECUTION**2.1 BUTTERFLY VALVES**

- A. Butterfly valves may be used in lieu of gate and globe valves at the contractor's option in chilled water, condenser water, and tempered water systems sizes 2½" and larger.

2.2 BALL VALVES

- A. Ball valves may be used in lieu of gate and globe valves at the contractor's option in chilled water, condenser water, and tempered water systems in pipe sizes 2" and smaller.

2.3 GENERAL

- A. Valves shall be line size unless otherwise noted.
- B. Gate, globe, and ball valves installed in horizontal piping shall have valve stems upright where possible. Butterfly valves shall be installed with the stem in the horizontal position where possible.
- C. Set pressure-reducing valves for pressures noted on the plans.

END OF SECTION 23 0523

**SECTION 23 0529
EQUIPMENT SUPPORTS**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the equipment support rails and pipe caps.

1.2 RELATED SECTIONS

- A. Section 23 0500 Common Work Results for HVAC
- B. Section 23 2113 Hydronic Piping
- C. Section 23 3100 Ductwork

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide shop drawing showing dimensions, materials of construction, size, and quantity provided.
- C. Provide manufacturer's instructions; indicate installation and support requirements.

PART 2: PRODUCTS

2.1 EQUIPMENT SUPPORT RAILS

- A. Rails shall be 12" high heavy gauge galvanized steel rails with continuously mitered and welded corners, raised cant, and galvanized counter flashing over pressure-treated wood nailer.
- B. Rails shall be PATE ES-5 or equivalent by Portals Plus, Roof Products and Systems, or Curbs Plus.

2.2 PIPE CAPS

- A. Pipe caps shall consist of heavy gauge galvanized steel curb with raised cant, insulated housing, wood nailer, and acrylic clad thermoplastic cover with graduated step boots and stainless-steel clamps.
- B. Pipe caps shall be PATE PCC series or equivalent by Portals Plus or Roofing Products and Systems.

PART 3: EXECUTION

3.1 ATTACHMENTS TO CURBS AND RAILS

- A. Bolt equipment with legs to equipment support legs at all support points.

END OF SECTION 23 0529

**SECTION 23 0549
VIBRATION ISOLATION**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This Section specifies vibration isolation requirements for Mechanical Systems.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions - HVAC
- B. Section 23 0500 Common Work Results for HVAC
- C. Section 23 0529 Equipment Supports

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide product data, including schedule of isolator type, associated equipment, and load at each point based on manufacturer's operating weight, and actual deflection at each loading point for each piece of isolated equipment.
- C. Provide manufacturer's installation instructions, including setting and anchoring instructions.

PART 2: PRODUCTS

2.1 MANUFACTURER

- A. All vibration isolation equipment shall be furnished by one manufacturer. Equipment shall be by Aeroflex (VMC), Amber/Booth (VMC), Mason, or Vibro-Acoustics (Swegon).

2.2 ISOLATION EQUIPMENT

- A. Isolation equipment selection shall be based on actual mechanical equipment to be installed, providing uniform load distribution and deflection.

2.3 ISOLATORS

- A. Isolators shall conform to the following:
 - 1. Type 1. Spring isolators, free standing, laterally stable, unhooded, bolt holes in base, top leveling bolt, and neoprene acoustical isolation pad on base. Horizontal to vertical stiffness ratio shall not be less than .8. Spring outside diameter shall not be less than .8 of the operating height. Minimum additional travel to solid shall not be less than 50% of rated deflection.
 - 2. Type 2. Isolators shall be similar to Type 1 except hooded. Isolators shall have, in addition to Type 1 requirements, vertical adjustable limit stops, and inserts to isolate limit stops from housing.
 - 3. Type 3. Neoprene double deflection base mount isolators with all metal surfaces covered, bolt holes, and ribbed top and bottom.
 - 4. Type 4. Double deflection neoprene hanger type isolator with neoprene bushing between hanger and rod housing to prevent metal to metal contact.

5. Type 5. Combination hanger isolator with spring and double deflection neoprene element in series and neoprene bushing in base to prevent metal to metal contact. Spring diameter shall not be less than .8 of the operating height. Springs should have a minimum deflection of 1", with not less than 50% additional travel to stop. Rod shall be able to swing 20° out of alignment before contacting housing.
6. Type 6. Twin sphere piping flexible connectors constructed of neoprene reinforced with multi-layer nylon tire cord fabric and galvanized ductile iron flanges. Isolators shall be complete with control cables and shall be rated for operation at 180 psi at 200°F.
7. Type 7. Molded neoprene isolator pad, waffle molded surface top and bottom, selected for loading of 40 psi unless noted otherwise. Pad shall be a minimum of ½" thick.
8. Isolators located on systems installed outdoors shall have weatherproof finish.

PART 3: EXECUTION

3.1 INSTALLATION

- A. There shall be no direct contact of isolated piping or equipment with shaft walls, floor slabs, partitions, or conduits.
- B. Where recommended by the manufacturer, isolator base plates shall be bolted to the structure or foundation. Bolting shall incorporate neoprene bushings and washers.
- C. After installation, verify isolators are properly adjusted, with springs perpendicular to bases or housing, adjustment bolts are tightened up on equipment mountings, and hangers are not cocked.

END OF SECTION 23 0549

SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the identification requirements for the mechanical systems.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 0500 Common Work Results for HVAC Systems
- C. Section 23 2113 Hydronic Piping
- D. Section 22 1005 Plumbing Piping and Drainage Accessories

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide product data showing label illustrations and application locations.

1.4 SUMMARY:

- A. Section includes:
 - 1. Plastic Coiled Pipe Markers.
 - 2. Pressure Sensitive Adhesive Pipe Markers.
 - 3. Duct Identification.
 - 4. Valve Tags and Schedules.
 - 5. Engraved Plastic Signs.
 - 6. Engraved Equipment Markers.
 - 7. Plastic Tags.

1.5 REFERENCES

- A. American National Standards Institute (ANSI): ANSI A13.1 Scheme for the Identification of Piping Systems, current edition.
- B. Department of Labor 29 CFR 1910.1200.

1.6 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each identification material and device required.
- B. Schedules: Submit valve schedule for each piping system, typewritten and produced on 8½" x 11" bond paper. Include valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and any variations for identification. In addition to framed copies, furnish extra copies for maintenance manuals as specified in Division 1.

1.7 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of identification products of types and sizes required, whose products have been in satisfactory use for a period of five (5) years.
- B. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification products.

PART 2: PRODUCTS

2.1 MECHANICAL IDENTIFICATION MATERIALS

- A. Provide manufacturer's standard products for each application as referenced in this section.

2.2 PIPE MARKERS

- A. Pressure-Sensitive Type: Provide manufacturer's standard preprinted, permanent adhesive, color-coded pressure sensitive vinyl labels complying with ANSI A13.1. Color-coded plastic adhesive flow directional arrow tape, full circle at both ends of the pipe marker, tape overlapped 1½". Use 1" tape for piping less than 2½", 2" tape for 2½" through 8" piping, and 4" tape for larger piping.
- B. Lettering: Comply with ANSI A 13.1 for piping system nomenclature. Abbreviate only as necessary to accommodate marker length.

2.3 PLASTIC DUCT MARKERS

- A. Pressure-Sensitive Type: Provide manufacturer's standard preprinted, 2¼" x 13", permanent adhesive pressure sensitive vinyl duct markers complying with ANSI A13.1 indicating duct service (supply, return, exhaust, etc.). Include separate directional arrows to indicate airflow.

2.4 VALVE TAGS

- A. Plastic Tags: Provide manufacturer's standard 1/16" plastic engraved tags, 1½" square, black with white lettering, with ¼" high service indicator on top line and ½" numbers below.
- B. Valve Tag Fasteners: Use solid brass "S" hooks for installation of valve tags.
- C. Chart Frames: Provide one (1) aluminum 8½" x 11" valve chart frame with glass lens for each valve schedule provided.
- D. Access Panel Markers: Provide manufacturer's standard 1/16" thick engraved plastic access panel markers with abbreviations and numbers corresponding to the concealed valve.

2.5 ENGRAVED PLASTIC EQUIPMENT MARKERS

- A. Provide manufacturer's standard 1/16" engraved equipment tags matching the terminology on schedules as closely as possible. Use black with white letters, 1" x 3" or 1½" x 4" for control devices, dampers, and valves and 4" x 6" for equipment. Use green with white letters, 3" long x the ceiling grid width for equipment above lay-in ceilings.

2.6 PVC JACKET

- A. Provide on all new piping insulation located in Mechanical Rooms and in spaces with no ceilings. Protective jacket shall be pre-molded, with color imbedded in factory PVC, high impact type, UV resistant, flame spread and smoke developed 25/50 rated per ASTM E 84 and shall have minimum 0.030" thickness. Manufacturers shall be Johns Manville, PIC-Plastics, Speedline, or Proto.

PART 3: EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. Where identification is to be applied to surfaces requiring painting, insulation, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

3.2 MARKER LOCATION

- A. Install pipe markers on each system indicated, include arrows showing normal direction of flow.
- B. Schedule of Piping Identification:

Piping Systems and Contents	Tape Background Color	Stenciled Legends
<u>Water Supply</u>		
Heating Hot Water	Yellow	Hot Water Supply/Return
Chilled Water	Blue	Chilled Water Supply/Return
Condenser Water	Green	Condenser

- C. Locate pipe markers and/or color bands (if required) wherever piping is exposed to view, and at least one marking per room above suspended ceilings. Per the following:
 1. Near each valve and control device.
 2. Near each branch, excluding short take-offs for fixtures and terminal units mark each branch where there might be a question of flow direction.
 3. Near locations where pipes pass through walls, floors, or ceilings or where they enter non-accessible locations.
 4. Behind removable panels and other access points permitting view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. On piping above removable acoustical ceilings.
 7. At maximum intervals of 40' along each straight pipe run, except to 25' in congested areas.

3.3 DUCTWORK IDENTIFICATION

- A. General: Identify air supply, return, exhaust, intake, and relief ductwork with duct markers as specified.
- B. Location: In each space where ductwork is exposed or concealed by removable ceilings. Locate markers near points where ductwork originates or continues into concealed enclosures, and at 50' spacing along exposed runs.
- C. Access Doors: Provide duct markers or signs on each access door in ductwork and housings indicating purpose of access (to what equipment), instructions, and appropriate safety and procedural information.

3.4 VALVE IDENTIFICATION

- A. Provide a valve tag on every, cock, and control device in each piping system. Exclude check valves and valves within factory fabricated equipment units. List each tagged valve in a valve schedule for each piping system.

3.5 EQUIPMENT IDENTIFICATION

- A. Install engraved plastic signs or equipment markers on or near each major item of mechanical equipment and each operational device, per the equipment schedule. Attached tag to the ceiling grid directly under equipment installed above lay-in ceilings. Provide markers for the following general categories of equipment and operational devices.
 - 1. Main control and operating valves including safety devices and hazardous units.
 - 2. Meters, gauges, thermometers, and similar units.
 - 3. Fuel burning units including boilers, furnaces, heaters, stills, and absorption units.
 - 4. Pumps, compressors chillers, condensers, and similar motor driven units.
 - 5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 - 6. Fans, blowers, primary dampers, and mixing boxes.
 - 7. HVAC central station and zone units.
 - 8. Tank and pressure vessels.
 - 9. Strainers, filters, humidifiers, water treatment systems, and similar equipment.
- B. Method of Installation: Use stainless steel screws except where adhesive is necessary because substrate cannot or should not be penetrated. Use rivets for tags attached to the ceiling grid.

END OF SECTION 23 0553

SECTION 23 0593
TESTING, BALANCING, AND ADJUSTING

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements for testing and balancing the Heating, Ventilating, and Air Conditioning Systems.

1.2 RELATED SECTION

- A. Section 23 0010 General Provisions HVAC

1.3 QUALIFICATIONS

- A. The test and balance work shall be performed by an independent firm certified by the Associated Air Balance Council (AABC), or National Environmental Balancing Bureau (NEBB).

1.4 PROCEDURES

- A. All air distribution systems and hydronic systems shall be tested, adjusted, and balanced to the conditions specified and/or shown on the drawings.
- B. Performance of systems and components at specified conditions shall be verified by testing.
- C. Before request for final inspection, calibrate, adjust, set, test and check all valves, dampers, temperatures, pressures, and flow rates of systems for operation and performance.
- D. All test and balance work shall be performed in accordance with AABC or NEBB procedures.

1.5 REPORTS: Submit completed and certified report to Architect in triplicate.

PART 2: PRODUCTS

2.1 GENERAL

- A. Provide all instruments, charts, materials, and equipment required to develop a complete test and balance report.

PART 3: EXECUTION

3.1 TEST AND BALANCE REPORT

- A. Test and balance report shall be a complete document, not limited to, but including at least the following:
 - 1. Air side of systems:
 - a. Coil entering and leaving temperatures.
 - b. All air unit component pressure drops.
 - c. Fan rpm and entering and leaving static pressure.
 - d. Air flow readings for all diffuser outlets and exhaust grilles.
 - e. Air flow and pressure drops for all terminals. Where heating coils are included, data shall be same as under Coils and Heat Exchangers.
 - f. Space temperatures at thermostats.

- g. Outlet temperatures of selected diffusers.
2. Coils, Pumps and Heat Exchangers:
 - a. Entering medium temperature, flow rate, and pressure.
 - b. Leaving medium temperature, flow rate, and pressure.
3. Pumps:
 - a. Flow rates.
 - b. Entering and leaving pressures.
 - c. Verify alignment.
 - d. Pump speed.
4. Electric Motors:
 - a. Full load amperes, voltage, and horsepower.
 - b. Installed starter heater size.
5. Controls:
 - a. Operational setting of controllers and instruments.
 - b. Positioning and function of valves and dampers.
 - c. Interlock and operation of system functions.
 - d. Thermostat differential setting.
6. Refrigeration System:
 - a. Compressor safety and operating controls.
 - b. Capacity reduction and low ambient controls.
 - c. Expansion valve superheat.
 - d. Operating pressure at each controller position.
 - e. Compressor full load amperage in each phase and voltage.
 - f. Condenser fan amperage and voltage, if applicable.
7. Fire Dampers: At selected dampers, blades will be dropped to prove close-off without binding.
8. Smoke and Fire/Smoke Dampers: Provide operation of all dampers on activation of smoke detectors or fire alarm signal.

3.2 DUCTWORK LEAKAGE TESTING

- A. A leakage test shall be conducted on all ductwork as scheduled below to demonstrate adequacy of construction tightness. Testing shall be done in the presence, and to the approval, of the Engineer/Owner. Each test section shall incorporate at least 50' of duct.
- B. Leakage in each type of ductwork shall not exceed:

Pressure Classification, "wg	Rectangular Ductwork Leakage Class	Round Ductwork Leakage Class	Amount to be Tested
4" and over	6	3	All
- C. Prior to testing, submit drawings indicating sections of ductwork to be tested.
- D. Coordinate leakage testing with contractor installing the ductwork to provide temporary blank-off panels where necessary.

- E. Leakage testing shall be performed in accordance with SMACNA HVAC Air Duct Leakage Test Manual, latest edition.
- F. Ductwork shall be tested prior to the installation of any insulation or concealing of duct.
- G. Ductwork failing test shall be repaired and retested until satisfactory.
- H. Contractor has the responsibility of coordinating the test with Testing and Balancing Contractor/Engineer/Commissioning Agent to witness and validate leakage testing. Ductwork failing test shall be reconstructed and retested until satisfactory, before additional ductwork is installed and before ductwork is concealed. Three to five days prior to each test, the sheetmetal subcontractor shall be required to submit marked-up shop drawings for the duct section to be tested, along with the allowable leaking calculations, as required by SMACNA.
- I. Additional tests of each pressure classification will be required, at the discretion of the Owner, T&B Contractor, Engineer, or Commissioning Agent, if subsequent ductwork installation becomes suspect and does not appear to maintain the same level of quality as the section tested.

3.3 BALANCING AND ADJUSTMENT AFTER FINAL INSPECTION

- A. After building is accepted and occupied, and after testing and preliminary balancing are completed, send qualified personnel to building for not less than one period during summer and one period during winter, observe temperatures throughout conditioned spaces, consult with Owner's representative as to need for additional balancing or adjustment, then perform such work as is indicated.
- B. Schedule these visits, at a time agreeable to Owner, during December through February for heating, and July through August for cooling.

END OF SECTION 23 0593

**SECTION 23 0700
HVAC INSULATION**

PART 1: GENERAL

1.1 DESCRIPTION

- A. Insulation specified in this Section is for insulation used in Division 23 work.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 2113 Hydronic Piping
- C. Section 23 2114 Hydronic Water Specialties
- D. Section 23 3100 Ductwork (ductliner requirements)
- E. Section 23 5631 Electric Boiler
- F. Section 23 5721 Plate Heat Exchanger

1.3 DEFINITIONS

- A. Exposed piping and ductwork is work that can be seen when the building is complete without opening or removing access doors or panels.
- B. Other piping and ductwork is considered to be concealed.

1.4 INSPECTION

- A. Surfaces to be insulated shall be clean, dry, and free of foreign material such as rust, scale, and dirt when insulation is applied. Perform pressure tests required by other Sections before applying insulation.
- B. Where existing insulation is damaged due to the new work, repair damage to match existing work or replace damaged portion with insulation specified for new work.

1.5 QUALITY ASSURANCE

- A. Products of the listed manufacturers will be acceptable for use for the specific functions noted. All materials shall be compatible with the materials to which they are applied, and shall not corrode, soften, or otherwise attack such material in either the wet or dry state.
- B. Materials shall be applied subject to their temperature limits. Any methods of application of insulating materials or finishes not specified in detail herein shall be in accordance with the particular manufacturer's published recommendations.
- C. Insulation shall be applied by experienced workers regularly employed for this type work.

1.6 RATING

- A. Insulation and accessories, unless specifically exempted, shall have a composite flame-spread rating of not more than 25 and a smoke-developed rating of not more than 50. Materials that are factory applied shall be tested as assembled. Materials that are field applied may be tested individually. No fugitive or corrosive treatments shall be employed to impart flame resistance.

- B. Flame-spread and smoke-developed ratings shall be determined by Method of Test of Surface Burning Characteristics of Building Materials, ASTM E-84 or UL 723.
- C. Products or their shipping cartons shall bear a label indicating flame-spread and smoke-developed ratings.
- D. Treatment of pipe jackets and duct facings to impart flame and smoke safety shall be permanent.

PART 2: PRODUCTS

2.1 INSULATION APPLICATIONS

- A. Duct Insulation – Denoted by Type D:
 - 1. Interior concealed supply ductwork:
 - a. Type D3 elastomeric, 1" thick.
 - b. Type D10 glass fiber, rigid, ASJ, 1½" thick.
 - 2. Interior exposed outside air (tempered) and exhaust ductwork in mechanical rooms connected to energy recovery units:
 - a. Type D2 glass fiber, rigid, FRK, 1½" thick.
 - b. Type D10 glass fiber, rigid, ASJ, 1½" thick.
 - 3. Interior exposed outside air ductwork in heated only mechanical rooms:
 - a. Type D2 glass fiber, rigid, FRK, 1½" thick.
 - b. Type D10 glass fiber, rigid, ASJ, 1½" thick.
 - 4. Exterior supply and return ductwork and exterior outside air (tempered) and exhaust ductwork connected to energy recovery units:
 - a. Type D4 elastomeric, with membrane, 2" thick.
 - 5. Interior concealed kitchen range hood or oven hood ductwork:
 - a. Type D5 flexible fire resistant ductwrap, 1½" thick.
 - b. Type D6 mineral fiber, 2 layers for a total of 4" thickness.
 - 6. Exterior kitchen range hood or oven hood ductwork, accessible to foot traffic:
 - a. Provide expanded metal screen around duct to shield against accidental skin contact with hot duct surface. Screen shall be 0.081" thick aluminum with .3" x 1" openings and secured to duct with 1" standoff.
- B. Mechanical Equipment: Insulation - denoted by Type E:
 - 1. Interior cold equipment (chillers, chilled water pumps, chilled water storage tanks, chilled water heat exchangers, or any other equipment subject to sweating):
 - a. Type E1 elastomeric, 1" thick.
 - b. Type E2 glass fiber, rigid, 1" thick.
 - 2. Interior hot equipment (converters, heat exchangers, flash tanks, or any equipment with surface temperatures above 130°F, except pumps and expansion tanks):

- a. Type E2 glass fiber, rigid, 2" thick.
- 3. Boiler breeching:
 - a. Type E3 calcium silicate, 2" thick.
- C. Pipe Insulation – Denoted by Type P:
 - 1. Interior concealed chilled water piping:
 - a. Type P1 cellular glass, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
 - b. Type P2 polyisocyanurate, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
 - 2. Interior exposed chilled water piping:
 - a. Type P1 cellular glass, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
 - b. Type P2 polyisocyanurate, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
 - 3. Exterior above grade chilled water piping or interior chilled water piping in an unconditioned space:
 - a. Type P5 cellular glass sizing per chart below:

Pipe Size	4"	6"	8"	10"	12"	14"	16"	18"
Mastic Finish	1½"	1½"	1½"	1½"	1½"	2"	2"	2"
Metal Jacket	2"	2½"	2½"	2½"	2½"	3"	3"	3"

- 4. Exterior below grade chilled water piping (field applied):
 - a. Type P7 cellular glass, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
- 5. Interior condenser (cooling tower) water piping:
 - a. Type P1 cellular glass, 1½" thick for piping up to 4" diameter and 2" thick for piping larger than 4" diameter.
 - b. Type P2 polyisocyanurate, 1" thick for piping up to 2" diameter and 1½" thick for piping larger than 2" diameter.
 - c. Type P3 glass fiber, rigid, 1" thick.
 - d. Type P4 glass fiber, wicking, 1" thick.
- 6. Exterior above grade condenser (cooling tower) water piping:
 - a. Type P5 cellular glass, 1½" thick.
 - b. Type P6 polyisocyanurate, 2" thick.
- 7. Interior concealed hydronic heating water piping:
 - a. Type P1 cellular glass, 1½" thick for piping up to 4" diameter and 2" thick for piping larger than 4" diameter.

- b. Type P2 polyisocyanurate, 1" thick for piping up to 2" diameter and 1½" thick for piping larger than 2" diameter.
 - c. Type P3 glass fiber, rigid, 1" thick for piping up to 2" diameter and 1½" thick for piping larger than 2" diameter.
8. Interior exposed hydronic heating water piping:
- a. Type P1 cellular glass, 1½" thick for piping up to 4" diameter and 2" thick for piping larger than 4" diameter.
 - b. Type P2 polyisocyanurate, 1" thick for piping up to 2" diameter and 1½" thick for piping larger than 2" diameter.
 - c. Type P3 glass fiber, rigid, 1" thick for piping up to 2" diameter and 1½" thick for piping larger than 2" diameter.
9. Exterior above grade Hydronic heating water piping:
- a. Type P5 cellular glass, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
 - b. Type P6 polyisocyanurate, 1½" thickness for piping up to 4" diameter and 2" for piping larger than 4" diameter.
10. Exterior below grade hydronic heating water piping (field applied):
- a. Type P7 cellular glass, 1½" thick for piping up to 4" diameter and 2" thick for piping larger than 4" diameter.
11. Interior condensate piping from coils and heat exchangers:
- a. Type P8 elastomeric tube, ¾" thick.
12. Interior concealed steam piping:
- a. Type P1 foam glass, 1½" thick for pipe up to 2" and 2" thick for all pipe larger than 2".
 - b. Type P3 glass fiber, 1½" thick for runouts (up to 2" size and max length of 12 ft.), 2" thick for pipe up to 1", 2½" thick for pipe 1¼" to 4", and 3½" thick for all pipe larger than 4".
 - c. Type P9 Calcium Silicate, 1½" thick for runouts (up to 2" size and max length of 12'), 2" thick for pipe up to 1", 2½" thick for pipe 1¼" to 4", and 3½" thick for all pipe larger than 4".
13. Interior concealed steam condensate piping:
- a. Type P1 foam glass, 1½" thick for pipe up to 1½", and 2" thick for all pipe larger than 2".
 - b. Type P3 glass fiber, 1½" thick for pipe up to 1½", 2" thick for pipe 2" to 6", and 3½" thick for pipe over 6".
 - c. Type P9 calcium silicate, 1½" thick for pipe up to 1½", 2" thick for pipe 2" to 6", and 3½" thick for pipe over 6".

2.2 ACCESSORY MATERIALS

- A. Low VOC adhesives, sealants and mastics shall be selected as recommended by the insulation manufacturer. Adhesives shall be water based, and must comply with the current VOC content limits of the South Coast Air Quality Management District (SCAQMD) Rule #1168, with a maximum VOC emission of 70 grams per liter. Low VOC water based sealants and mastics shall be manufactured to comply with NFPA 90A, UL listed and complying with ASTM E84 and comply with the current VOC limits of the SCAQMD Rule #1168, with a maximum VOC emission of 250 grams per liter. They shall be manufactured by the insulation manufacturer or by Foster, Hardcast, or 3M.
- B. Adhesives, sealants and mastics which secure a vapor barrier material shall be of the vapor barrier type.
- C. Adhesives, sealants and finishes for surfaces above 70°F shall be of the “breather” type.
- D. Insulation jackets shall have a vapor barrier when applied to surfaces subject to sweating in an ambient environment up to 90°F D.B. and 80°F W.B., including chilled water, condensate drain, refrigerant suction, and ice water.
- E. Where specified, finish jackets for all insulation in the building shall be not less than 8 oz./sq. yd. white, pre-sized glass cloth kraft paper reinforced by Carolina or Twinsburg-Miller.
- F. All finish mastics and sealants shall be white in color, unless noted otherwise.
- G. Pre-formed fitting jackets shall be one piece molded PVC with a 25/50 flame spread smoke developed rating.
- H. Aluminum jackets shall be corrugated type, .010” thick for pipe 8” and under, and .016” thick for 10” and over. Provide pre-formed aluminum jackets at fittings.
- I. T-304 stainless steel jackets shall be corrugated type, with 3/16” corrugations, .016” thick for all pipe sizes. T-304 stainless steel jacketing shall have an integrally bonded moisture barrier over the surface in contact with the insulation. Provide two-piece pre-formed T-304 stainless steel at fittings.
- J. Staples shall be “outward clinch” or “flare” type.
- K. Galvanized steel wire shall be 20 gauge.
- L. Stainless steel wire shall be 20 gauge.

2.3 INSULATION PIPE SHIELDS

- A. Shields shall be galvanized rolled to form a 180° arc. Length of shields shall conform to the following:

<u>Insulation O.D.</u>	<u>Shield Length</u>	<u>Shield Gauge</u>
0-4”	12”	14 gauge
5-9”	18”	14 gauge
10-19”	24”	12 gauge
Over 20”	30”	12 gauge

2.4 INSULATION DESIGNATION

- A. Type D1 shall be Glass Fiber Insulation, flexible, suitable for interior application.

1. Insulation shall be composed of one lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 40°F to 250°F. Mean thermal conductivity shall not exceed 0.27 at 75°F. Manufacturer shall be Certainteed, Knauf, Owens Corning, or Johns Manville.
 2. Insulation finish shall be factory applied foil/scrim reinforced kraft (FSK) jacket with longitudinal flap for butt-joint closure. Jacket permeance shall not exceed 0.02 perms.
- B. Type D2 shall be Glass Fiber Insulation, rigid, suitable for interior application.
1. Insulation shall be composed of three lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 0°F to 650°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Manufacturer shall be Certainteed, Knauf, Owens Corning, or Johns Manville.
 2. Insulation finish shall be factory applied foil/scrim reinforced kraft (FRK) jacket. Jacket permeance shall not exceed 0.02 perms.
- C. Type D3 shall be Elastomeric Insulation, suitable for interior application.
1. Elastomeric sheet and tape shall be a closed-cell rubber material with a minimum density of 3.0 lbs./cu.ft. Operating temperature range shall be -70°F to 180°F, with a mean thermal conductivity of 0.27 at 75°F. Material shall have a water vapor permeability not exceeding 0.08 perm-inch and shall resist mildew development. Flame spread rating shall not exceed 25 and smoke-developed rating shall not exceed 50. Manufacturer shall be Armacell (Armaflex) or Rubatex.
- D. Type D4 shall be Elastomeric Insulation with membrane, suitable for exterior application.
1. Elastomeric sheet and tape shall be a closed cell rubber material with a minimum density of 3.0 lbs./cu.ft. Operating temperature range shall be -70°F to 180°F, with a mean thermal conductivity of 0.27 at 75°F. Material shall have a water vapor permeability not exceeding 0.08 perm-inch and shall resist mildew development. Flame spread rating shall not exceed 25 and smoke developed rating shall not exceed 50. Manufacturer shall be Armacell (Armaflex) or Rubatex.
 2. Single ply membrane jacket shall be .060" thick self-adhering rubberized bitumen membrane in the largest sheet possible. The membrane shall conform to the minimum physical properties of ASTM D882, D1000 & E154. Single ply membrane jacket shall be Alumaguard 60 by Polyguard Products or equivalent.
- E. Type D5 shall be flexible fire-resistant duct wrap, suitable for interior applications.
1. Flexible fire-rating duct wrap shall be a UL-listed foil-encapsulated, non-combustible, flexible fire-resistant wrap with a thermal resistance R value of 4.15 per inch at 70°F per ASTM C 518. Flame spread shall not exceed 5 and smoke developed rating shall not exceed 5. Duct wrap must comply with NFPA 96, current edition, and tested in accordance with UL 1978 (Sections 12 & 13). Manufacturer shall be 3M Fire Barrier Duct Wrap, FireMaster, ETS Schafer Flameshield blanket, or Johns Manville Firetemp L.
- F. Type D6 shall be mineral fiber insulation, suitable for interior application:
1. Mineral fiber shall be asbestos free 6 lb./cu.ft. density wire mesh reinforced mineral wool blanket, semi rigid, with thermal conductivity of not more than 0.24 at 75°F. Operating temperature range shall be 0°F to 1200°F. Manufacturer shall be Owens Corning.
- G. Type D8 shall be Glass Fiber Insulation, low VOC, flexible, suitable for interior application.

1. Insulation shall be composed of one lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 40°F to 250°F. Mean thermal conductivity shall not exceed 0.27 at 75°F. Product shall be certified by Greenguard® for VOC emissions below recommended levels. Manufacturer shall be Certainteed, or Knauf.
 2. Insulation finish shall be factory applied foil/scrim reinforced kraft (FSK) jacket with longitudinal flap for butt joint closure. Jacket permeance shall not exceed 0.02 perms.
- H. Type D9 shall be Glass Fiber Insulation, low VOC, rigid, suitable for interior application.
1. Insulation shall be composed of three lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 0°F to 650°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Product shall be certified by Greenguard® for VOC emissions below recommended levels. Manufacturer shall be Certainteed, Knauf, Owens Corning, or Johns Manville.
 2. Insulation finish shall be factory applied foil/scrim reinforced kraft (FSK) jacket. Jacket permeance shall not exceed 0.02 perms.
- I. Type D10 shall be Glass Fiber Insulation, rigid, suitable for interior application.
1. Insulation shall be composed of three lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 0°F to 650°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Manufacturer shall be Certainteed, Knauf, or Owens Corning.
 2. Insulation finish shall be factory applied white all service jacket (ASJ). Jacket permeance shall not exceed 0.02 perms.
- J. Type E1 shall be Elastomeric Insulation, suitable for interior application.
1. Elastomeric sheet and tape shall be a closed cell rubber material with a minimum density of 3.0 lbs./cu.ft. Operating temperature range shall be -70°F to 180°F, with a mean thermal conductivity of 0.27 at 75°F. Material shall have a water vapor permeability not exceeding 0.08 perm-inch, and shall resist mildew development. Flame spread rating shall not exceed 25 and smoke developed rating shall not exceed 50. Manufacturer shall be Armacell (Armaflex) or Rubatex.
- K. Type E2 shall be Glass Fiber Insulation, suitable for interior application.
1. Insulation shall be composed of three lb./cu.ft. density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 0°F to 650°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Manufacturer shall be Certainteed, Knauf, Owens Corning, or Johns Manville.
 2. Insulation finish shall be factory applied all service jacket (white). Jacket permeance shall not exceed 0.02 perms.
- L. Type E3 shall be Calcium Silicate insulation, suitable for interior application.
1. Insulation shall be composed of hydrous, calcium silicate molded in sections or blocks. The product shall be asbestos free and shall comply with ASTM Designation C-533-95. Temperature range shall include 70°F to 1200°F. Mean thermal conductivity shall not exceed 0.51 at 400°F. Manufacturer shall be Manville or Owens Corning Fiberglass.
- M. Type P1 shall be Cellular Glass Insulation, suitable for interior application.

1. Insulation shall be composed of multiple glass cells each of which is a sealed air cell and each cell sealed to the adjacent cells. Minimum density shall be 7 lbs./cu.ft. Temperature range shall include -450°F to 800°F per ASTM C552. Mean thermal conductivity shall not exceed 0.29 at 75°F. Absorption of moisture shall be not more than 0.2% by volume when tested according to ASTM Designation C-240-61. Adhesive shall be compatible with temperature range of pipe service. Manufacturer shall be Pittsburgh Corning or Cellutech Cellufoam.
 2. Insulation finish shall be glass fabric and mastic jacket, Pittsburgh Corning PC Fabric 79 and Pittcote 404, or equivalent by Foster.
 3. All valves, thermometer wells, gauge cocks, hose bibbs, air vent piping, and any other components shall be insulated with molded insulation fittings or same thickness elastomeric insulating tape finished with flexible glass cloth and mastic.
- N. Type P2 shall be Polyisocyanurate Foam Insulation, suitable for interior application.
1. Insulation shall be a continuously molded rigid foam polyisocyanurate cellular plastic composed of multiple cells each of which is a closed air cell. Minimum density shall be 2.0 lbs./cu.ft. Temperature range shall include -40°F to 300°F per ASTM D2126. Mean, aged-rated thermal conductivity shall not exceed 0.20 at 75°F. Absorption of moisture shall be not more than 0.2% by volume when tested according to ASTM Designation C-272. Flame spread rating shall not exceed 25 and smoke developed rating shall not exceed 50 for 1" thickness as tested by ASTM E84. Manufacturer shall be HiTherm or equivalent.
 2. Insulation finish shall be six mil Saran industrial film with pressure sensitive adhesive closures for the longitudinal and butt joints. Jacket permeance shall not exceed 0.02 perms. Film not required for hydronic heating systems.
 3. Exposed insulation shall be covered with paintable PVC protective jacket, minimum 20 mil thick. Straight pieces and fittings shall be secured by solvent welding.
 4. All valves, thermometer wells, gauge cocks, hose bibbs, air vent piping, and any other components shall be insulated with molded insulation fittings or same thickness elastomeric insulating tape finished with flexible glass cloth and mastic.
- O. Type P3 shall be Glass Fiber Insulation, suitable for interior application.
1. Insulation shall be composed of high-density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 0°F to 850°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Manufacturer shall be Certainteed, Knauf, Owens Corning, or Johns Manville.
 2. Insulation finish shall be factory-applied all service jacket with pressure sensitive adhesive closures for the longitudinal and butt joints. Jacket permeance shall not exceed 0.02 perms.
 3. All valves, thermometer wells, gauge cocks, hose bibbs, air vent piping, and any other components shall be insulated with molded insulation fittings or same thickness elastomeric insulating tape finished with flexible glass cloth and mastic.
 4. Provide PVC jacket on insulation where piping is exposed to building occupants. Protective jacket shall be paintable white PVC, high impact type, UV resistant, flame spread and smoke developed 25/50 rated per ASTM E 84 and shall have minimum 0.020" thickness.
- P. Type P4 shall be Glass Fiber Insulation with wicking material, suitable for interior application.
1. Insulation shall be composed of high-density glass fibers bonded with a thermosetting resin. Operating temperature range shall be 32°F to 220°F. Mean thermal conductivity shall not exceed 0.23 at 75°F. Manufacturer shall be Owens Corning.

2. Wicking material shall encircle the interior surface of the insulation and transfer condensate to the exterior surface of the insulation. Provide additional wicking material to wrap piping accessories per manufacturer's recommendations.
 3. Insulation finish shall be factory applied polymer facing with pressure sensitive adhesive closures for the longitudinal and butt joints. Jacket permeance shall not exceed 0.15 perms.
 4. All valves, thermometer wells, gauge cocks, hose bibbs, air vent piping, and any other components shall be insulated with molded insulation fittings or same thickness elastomeric insulating tape finished with flexible glass cloth and mastic.
- Q. Type P5 shall be Cellular Glass Insulation, suitable for exterior application. This includes piping in an outdoor pit or vault.
1. Insulation and finish shall be same as Type P1.
 2. Stainless steel jackets shall be corrugated type, .016" thick for all pipe 8". Provide two-piece pre-formed stainless steel jacket at fittings.
- R. Type P6 shall be Polyisocyanurate Foam Insulation, suitable for exterior application.
1. Insulation and finish shall be same as Type P2.
 2. Aluminum jackets shall be corrugated type, .010" thick for pipe 8" and under, and .016" thick for 10" and over. Provide pre-formed aluminum jackets at fittings.
- S. Type P7 shall be Cellular Glass Insulation, suitable for direct burial application.
1. Insulation and finish shall be same as Type P1.
 2. Finish jacketing for all insulation located below ground shall be self-sealing, 50 mil thick modified bituminous resin reinforced woven glass fabric covered with 1 mil thick aluminum top film and release paper, Pittsburgh-Corning Pittwrap CW PLUS. All pipe fittings shall be covered with five (5) layers of Pittsburgh-Corning Pittcote 300 coating with Pittsburgh-Corning Fabric 79 open mesh synthetic fabric. Alternate layers of fabric and mastic cut to match fittings and build up a minimum wet film thickness of ¼".
 3. Install 0.016" thick smooth aluminum jacket with ½" aluminum bands 12" O.C. At all pipe fittings provide pre-formed aluminum fittings. Seal all aluminum jacket joints with 2 coats of bitumastic.
- T. Type P8 shall be Elastomeric Insulation, suitable for interior application.
1. Elastomeric tube and tape shall be a closed cell rubber material with a minimum density of 3.0 lbs./cu.ft. Operating temperature range shall be -70°F to 180°F, with a mean thermal conductivity of 0.27 at 75°F. Material shall have a water vapor permeability not exceeding 0.08 perm-inch and shall resist mildew development. Flame spread rating shall not exceed 25 and smoke developed rating shall not exceed 50. Manufacturer shall be Armacell (Armaflex) or Rubatex.
- U. Type P9 shall be Calcium Silicate insulation, suitable for interior application.
1. Insulation shall be composed of hydrous, calcium silicate molded in sections or blocks. The product shall be asbestos free and shall comply with ASTM Designation C-533-95. Temperature range shall include 70°F to 1200°F. Mean thermal conductivity shall not exceed 0.51 at 400°F. Manufacturer shall be Johns Manville.
 2. Aluminum jackets shall be corrugated type, .010" thick for pipe 8" and under, and .016" thick for 10" and over. Provide pre-formed aluminum jackets at fittings.
- V. Type P10 shall be Elastomeric Insulation, suitable for exterior application.
1. Insulation shall be same as Type P8.

2. Aluminum jackets shall be corrugated type, .010" thick for pipe 8" and under (including refrigerant piping if required), and .016" thick for 10" and over. Provide pre-formed aluminum jackets at fittings.

PART 3: EXECUTION

3.1 GENERAL APPLICATION

- A. The following general conditions apply to the insulation installation.
 1. Insulation shall be clean and dry during installation and during application of any finish.
 2. Provide removable and replaceable covers on all pumps and equipment requiring insulation that must be opened periodically for inspection, cleaning, or repair.
 3. Install insulation, jackets, and coatings continuous through wall and floor openings and sleeves. See Section 23 0500 regarding fire barrier sealing over insulated pipes passing through rated floors and walls.
 4. Banding wires shall have the twisted terminals turned down into the insulation, except where vapor barrier would be punctured.
 5. Finish open ends of pipe insulation as specified for fittings.
 6. All piping, ductwork, and equipment which are scheduled to be insulated shall have a finished jacket, either factory or field applied.
 7. Staples shall be installed only on insulation that does not contain a vapor barrier.
 8. For all cold piping systems (chilled water, condensate, and domestic cold water), all components of the piping system shall be insulated and provided with a continuous vapor barrier. Vapor barriers shall be continuous for entire piping system and shall not be pierced except as specified otherwise.
 9. Factory applied jacket shall be the finish jacket unless otherwise noted.
 10. Maintain vapor barrier where dissimilar insulation products abut.
 11. Lined ductwork is not required to be insulated externally. Where lined and insulated duct meet duct, liner shall overlap, minimum 4".
 12. Control devices shall be installed on the outside surface of insulation except devices such as firestats. All resulting penetrations and edges of insulation shall be sealed as specified above.
 13. No insulation materials shall be in direct contact with supply, return or exhaust airstreams.

3.2 PIPE SHIELDS

- A. For all piping, insulation shall be continuous on pipe at pipe hangers with protection shields bearing on the outside of the insulation.
- B. For pipes 2" and larger, where insulation would be crushed by hangers, provide 180° foamed glass inserts between pipe and hanger protector and finish with jacket same as adjacent pipe.

3.3 INSULATION APPLICATION

- A. Type D1 and Type D8 – Glass Fiber, flexible Insulation:
 1. Blanket insulation shall be installed with not less than 1" of insulation cut back from the edge of vapor barrier. Vapor barrier shall then overlap the adjacent insulation and vapor barrier at each and every abutting joint. Overlaps shall be sealed with adhesive. In addition, all joints in the vapor barrier such as at hangers and supports shall be sealed with aluminum foil tape.
 2. All blanket insulation shall be held in place with 3" wide adhesive tape at not over 12" intervals.

3. Where duct greatest dimension is more than 24" but less than 48", insulation shall also be tightly wrapped with galvanized wire, 24" on center. Where duct greatest dimension is more than 48", 2" wire mesh shall also be secured to the duct with mechanical fasteners at not more than 2'-0" center to center in two directions.
- B. Type D2, D9, D10 – Glass Fiber, rigid Insulation:
1. All rigid board insulation shall be secured by mechanical fasteners spaced on not more than 18" centers in two directions. Provide metal corner beading at each corner.
 2. Insulation thicknesses specified are minimum values. All projections, duct stiffeners, etc., shall be covered with not less than ½" thickness of insulation. Surface of insulation shall be smooth without bumps, etc. Vapor seal materials shall pass such obstructions without interruption.
- C. Type D3 – Elastomeric Insulation:
1. Foamed plastic insulation shall be cut into shaped sections and applied over 100% surface coverage of adhesive. Insulation shall be applied when surface is clean and dry. Butt joints together in a staggered fashion and butter with adhesive before joining to provide a continuous vapor barrier jacket. Install insulation with the skin side outside.
- D. Type D4 – Elastomeric Insulation:
1. Same as Type D3. Apply membrane per manufacturer's recommendations.
- E. Type D5 – Flexible Fireresistant Ductwrap Insulation:
1. Wrap duct with of insulation with a 3" overlap of the circumferential and longitudinal joints.
 2. The insulation shall be held in place with 1/2" wide stainless steel bands or insulation pins welded to the duct, spaced at 10" on center or as recommended by the manufacturer.
 3. For duct dimensions greater than 24", insulation pins shall be installed at the bottom of the horizontal runs and on vertical runs to prevent blanket sag.
 4. Completely seal duct penetration at roof with firestop materials per manufacturer's recommendations.
 5. Provide access panels in insulation and sheet metal at all range hood duct cleanout locations. Insulate and secure access panel per manufacturer's recommendations.
- F. Type D6 – Mineral fiber Insulation:
1. Wrap 16 gauge welded exhaust duct with two layers of insulation. Insulation shall be held in place with welded pins, spaced no more than 16" on center or a maximum of 4" from edge of duct. Cover insulation with and 2" hexagonal wire mesh and support with galvanized bands 18" on center. Joints shall be staggered and butted together.
 2. Completely seal duct penetration at roof with firestop materials per manufacturer's recommendations.
 3. Provide access panels in insulation and sheet metal at all range hood duct cleanout locations. Insulate and secure access panel per manufacturer's recommendations.
- G. Type E1 – Elastomeric Insulation:
1. Foamed plastic insulation shall be cut into shaped sections and applied over 100% surface coverage of adhesive. Insulation shall be applied when surface is clean and dry. Butt joints together in a staggered fashion and butter with adhesive before joining to provide a continuous vapor barrier jacket. Install insulation with the skin side outside.

H. Type E2 – Glass Fiber, rigid Insulation:

1. All rigid board insulation shall be secured by mechanical fasteners spaced on not more than 18" centers in two directions.
2. Insulation thicknesses specified are minimum values. All projections shall be covered with not less than ½" thickness of insulation. Surface of insulation shall be smooth without bumps, etc. Vapor seal materials shall pass such obstructions without interruption.

I. Type E3 – Calcium Silicate Insulation:

1. Insulation shall be applied in two 1" layers with joints staggered and butted together. Cover insulation with 2" hexagonal wire mesh and support with galvanized bands 18" on center.
2. Fittings shall be insulated with mitered sections of insulation cut to fit and wired tightly in place.
3. Finish insulation with corrugated aluminum jacket and fitting covers held in place with bands 18" O.C.
4. Insulation shall terminate at the roof collar.

J. Type P1 - Cellular Glass Interior Insulation:

1. Cover pipe with insulation held in place with stainless steel wire not more than 12" on center.
2. All joints shall be filled and pointed up with Pittseal (R) 44N sealant, or equal, applied so as to maintain continuous vapor barrier.
3. All pipe insulation on exposed piping inside the building shall be finished with a coating of Pittcote (R) 404 coating, or equal. For cold piping, coating shall be vapor barrier type.
4. All pipe insulation on concealed piping shall be finished with two coats of mastic with flexible glass cloth embedded in the initial layer. For cold piping, sealer shall be vapor barrier type.
5. Valves, fittings and unions shall be covered and finished with mitered insulation sections as described for pipe: Maintain specified insulation thickness.
6. Riser clamps, anchors, etc., which are in contact with cold pipe shall be insulated with cellular glass as described for piping extending for a distance of 6" beyond the outside surface of the pipe insulation.

K. Type P2 – Polyisocyanurate Interior Insulation:

1. Cover piping with joints butted together, and longitudinal joint tightly closed. Seal longitudinal lap and provide butt joint vapor barrier strips over the joint secured with adhesive.
2. Insulate fittings and valves with mitered sections of insulation cut to fit together without voids and wired in place. Preformed molded fittings may be used if material is the same thickness as adjoining insulation.
3. Cover pipe with insulation with each section tightly abutted one to another. Jacket shall be lapped and secured with self-adhesive strip.
4. Abutting ends of insulation shall be covered with 4" wide butt strips smoothly secured with adhesive.
5. Fittings and valves shall be covered with mitered or molded insulation sections secured with galvanized steel wire and finished with smooth coat of white glass fabric and mastic.
6. Fittings and valves shall be covered with mitered or molded insulation sections secured with galvanized steel wire and finished with a preformed PVC jacket stapled in place.

L. Type P10 - Elastomeric Insulation:

1. Same as Type P8. Aluminum jacket shall be installed with the seam on the underside of the pipe. Aluminum bands shall be installed at each joint and at the midpoint of each jacket section. Waterproof fabric and mastic as specified above shall be used on fittings.

3.4 FINISH JACKETS

- A. Field installed jackets shall be provided when specifically noted.
- B. Pre-sized glass cloth jackets shall be secured by a continuous coating of adhesive applied to a uniform thickness. Jacket shall be smooth without wrinkles. Jacket shall be applied to straight lengths of covering only.
- C. Flexible glass cloth shall be applied to equipment, valves, fittings, and curved surfaces. Cloth tape shall be smoothly applied and secured with a continuous coat of adhesive. White fabric and mastic to be used on exposed pipe fittings. Tape shall overlap itself and adjacent jackets not less than 2".

END OF SECTION 23 0700

SECTION 23 0923
BUILDING AUTOMATION AND TEMPERATURE CONTROL SYSTEM

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements of the Building Automation and Temperature Control System (BAS). The BAS shall utilize direct digital control (DDC) technology to maintain the space conditions and provide automatic control of the associated mechanical equipment.

1.2 SCOPE OF WORK

- A. Furnish and install a complete building automation system in all respects, including any and all equipment, wiring, instrumentation, enclosures, labor, engineering, coordination with other trades, etc. No information given in these specifications shall relieve the contractor of this absolute requirement. Include all associated electrical work. It is the intent of these specifications that the Contractor shall furnish and install the systems complete in every respect and ready to operate. Furnish and install equipment, miscellaneous items, and accessories required for the correct and convenient operation of the entire installation, whether or not such item is shown on the plan or mentioned herein.

1.3 CODES AND STANDARDS

- A. Codes and Standards: Meet requirements of all applicable standards and codes, except when more detailed or stringent requirements are indicated by the Contract Documents, including requirements of this Section.

1. Underwriters Laboratories: Products shall be UL-916-PAZX listed.
2. National Electrical Code -- NFPA 70.
3. Federal Communications Commission -- Part J.
4. ASHRAE/ANSI 135-2012 (BACnet) - (System Level Devices) - Building Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.
5. ASHRAE/ANSI 135-2012 (BACnet) - (Unit Level Devices) - Unit Controllers shall conform to the listed version of the BACnet specification in order to improve interoperability with various building system manufacturers' control systems and devices.

B. Work Included:

1. System engineering and design documents.
2. Pre-assembled control panels.
3. System programming.
4. Actuators, thermostats, sensors, thermowells, and mounting hardware as applicable.
5. Control valves, control dampers, linkages, and mounting hardware.
6. Construction supervision.
7. Start-up and system check out.
8. Demonstration and training.
9. Warranty.

1.4 RELATED SECTIONS

- A. Section 23 0500 Common Work Results for HVAC

- B. Section 23 5631 Electric Boiler
- C. Section 23 6500 Cooling Towers
- D. Section 23 8146 Heat Pumps – Water Cooled

1.5 SERVICE PERFORMANCE STANDARDS

- A. The Building Performance Service must be capable of:
 - 1. Continuous collection of building data, 24 hours per day, 7 days a week.
 - 2. Remote access to building/system data, 24 hours per day, 7 days a week.

- B. Data Collection Standards:
 - 1. Communication architecture shall allow data to be collected by hardwired, or wireless, direct connection to range of gateways including:
 - a. Tridium (Niagara) platforms: JENE, JACE or other
 - b. Tracer SC
 - c. JCI NAE
 - d. Seimens

 - Performance Service shall use “push” technology to communicate with and send data to the central server, requiring limited outbound ports.

 - Data shall be stored in a Class 5 secure hosting location protected by ISO 5001-complaint firewall and intrusion detection systems with support for major network security protocols such as HTTPS and SFTP to securely access and store data.

 - Remote connection shall occur through a virtual private network (VPN) in order to provide network security. Should not require access to the customer’s own VPN.
 - Must use encryption level 256 bit Advanced Encryption Standard (AES)
 - Must use SSL/TLS for key exchange authentication

1.6 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Drawings:
 - 1. Prepare instrumentation and control diagrams labeled accurately and showing the system architecture and the interrelationship of all controls and the areas and equipment served. Clearly show point-to-point connections.

2. Wiring diagram shall delineate between power and control wiring and shall indicate all starters, contactors, relays, sensors, and other components of the system. Normally open positions for valves, dampers, and relays shall be indicated. All wiring between equipment, modules, and control panels shall be shown. A ladder diagram detailing control functions shall be included.
- C. Submit the above diagrams as post construction control record drawings derived from redlined prints maintained during construction by this Contractor.
- D. One (1) copy of the control record drawing shall be secured to the associated control panel. Mounting diagram(s) in a resealable plastic pouch is acceptable.
- E. Submit shop drawings and manufacturer's data for the following:
1. Sensors.
 2. Controllers and set points.
 3. Actuators.
 4. Automatic control valve and damper schedules.
 5. Points List.
 6. Thermostats.
 7. Thermometers and indicators.
 8. System diagrams, including system architecture.
 9. Point-to-point wiring or tubing diagrams.
 10. Control panels and panel layout.
 11. Installation and calibration instructions.
 12. Software programs and sequences written in the program language and in English.
- F. Operating and Maintenance Data (after construction):
1. Submission: Submit three (3) 8½" x 11", 3-ring, hard cover, bound and typed copies of Operating and Maintenance Manual to the Architect for approval prior scheduling any systems demonstration for the Owner.
 2. Required Contents: Typed index with tab dividers for each major equipment section to facilitate locating information on specific pieces of equipment. Identify data within each section with drawing code numbers as they appear on Drawings and Specifications. Include as a minimum the following data:
 - a. Alphabetical list of system components with the name, address, and 24-hour telephone number of the company responsible for servicing each item during the first one year of operation.
 - b. Operating instructions for each piece of equipment and the complete system including:
 - 1) Emergency procedures for fire or failure.
 - 2) Start, operation, maintenance, disassembly, and shutdown procedures.
 - 3) Maintenance instructions for each piece of equipment.
 - 4) Valve tags and other identified equipment lists.
 - 5) Proper lubricants and lubricating instructions.
 - 6) Cleaning, replacement and/or adjustment schedule.
 - 7) Product data on each piece of equipment.
 - 8) Installation instructions.
 - 9) Manufacturer's shop drawings and specifications.
 - 10) Parts list.
 - 11) Wiring and temperature control diagrams "as-built" as detailed above.

1.7 QUALITY ASSURANCE

- A. Control installation work shall be performed by mechanics regularly employed in the installation of the control manufacturer. Control work shall be by Trane Tracer or approved equal by Carrier Johnson Control, Control Concepts Inc., or Siemens.

1.8 SUBMITTAL REQUIREMENTS

- A. BAS manufacturer shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software being provided for this project. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications. Five (5) copies are required. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats once they have been approved and as-built drawings have been completed.
- B. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the BAS manufacturer of furnishing quantities required based upon contract documents.
- C. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be installed.
- D. Submit the following within 90 days of contract award:
1. A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers.
 2. A schedule of all control valves including the valve size, pressure drop, model number (including pattern and connections), flow, CV, body pressure rating, and location.
 3. A schedule of all control dampers including damper size, pressure drop, manufacturer, and model number.
 4. Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Include:
 - a. Building Controllers
 - b. Custom Application Controllers
 - c. Application Specific Controllers
 - d. Operator Workstations
 - e. Portable Operator Terminals
 - f. Auxiliary Control Devices
 5. Provide proposed Building Automation System architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements
 6. Provide detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.
 7. Provide points list showing all system objects and the proposed English language object names.
 8. Provide a sequence of operation for each controlled mechanical system and terminal end devices.
 9. Provide a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet system level device (i.e. Building Controller & Operator Workstations) type. This defines the points list for proper coordination of interoperability with other building systems if applicable for this project.

10. Provide LonMark Certification and functional profile SNVT's for unitary-level controllers (i.e. chillers, RTU's, AHU's, Terminal VAV boxes, FCU's, UV's, etc.) for interoperability with other building systems if applicable for this project.
- E. Project Record Documents: Upon completion of installation, submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:
1. Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .dwg and .pdf drawing files shall be provided.
 2. Testing and Commissioning Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BAS) commissioning personnel.
 3. Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:
 - a. Names, address and 24-hour/7-day per week telephone numbers of Contractor personnel managing and installing equipment, along with service personnel responsible for supporting the ongoing warranty and services of the control system.
 - b. Procedures for operating the BAS including logging on/off, alarm management, generation of reports, trends, overrides of computer control, modification of setpoints, and other interactive system requirements.
 - c. Description of the programming language including syntax, statement descriptions, algorithms, calculations, point database creation and modification, program creation and modification, and operator use of the editor.
 - d. Explanation of how to design and install new points, new DDC controllers, and other BAS hardware.
 - e. Preventative Maintenance and calibration procedures; hardware troubleshooting; and hardware repair and/or replacement procedures.
 - f. Documentation of all software program logic created for Custom Programmable Controllers including the overall point database. Provide one set of magnetic media containing files of the software and point database.
 - g. One set of electronic media containing files of all operator color graphic screens for the project.
 - h. A list of recommended spare parts including pricing, manufacturer, supplier, and part numbers.
 - i. Documentation, installation, and maintenance information for all third party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
 - j. Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
 - k. Licenses, Guarantee, and Warranty documents for all equipment and systems.
 - l. Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) and task descriptions.
- F. Training Manuals: The BAS manufacturer shall provide a course outline and copies of training manuals at least two weeks prior to the start of any corporate training class to be attended by the Owner.

1.9 WARRANTY REQUIREMENTS

- A. Warrant all work as follows:

1. BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BAS is operational and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates.
4. End of Warranty Performance Report - Prior to the end of the first-year warranty period the BAS vendor shall provide an analytics report. The ideal time frame for this report will be 6 to 9 months after substantial completion.

1.10 WARRANTY

- A. Provide a one (1) year labor and material warranty from date of system acceptance by Owner. Warranty shall cover hardware, software, and programming. The contractor shall correct any work found defective or not in accordance with the contract documents.
- B. The contractor shall provide all maintenance including parts, labor, and expenses for correction of any deficiency, breakdown, and routine preventative maintenance for the one (1) year warranty period.
- C. Provide written guarantee the system will be upwardly compatible for at least five (5) years without requiring wholesale replacement of hardware to upgrade to new generations. Failure to provide guarantee will result in immediate rejection of bid and proposal.
- D. Components: All system components shall be approved and listed by Underwriters Laboratories under UL916 for Direct Digital Control systems, and FCC-Part 15, Subparagraph J, Class A Emissions Requirements.

PART 2: PRODUCTS

2.1 SENSING/CONTROL FIELD DEVICES

- A. Field devices include all sensors, wells, relays, pressure switches, control valves, valve actuators, dampers, damper actuators, and other interfaces necessary for connecting the DDC panels to the facility equipment to be controlled under this specification.
- B. Analog Electronic Transmitters:

Limit of error:	± 0.50% of span
Deviation from Linearity	± 0.50% of span
Hysteresis	± 0.10 % of span
Deadband	± 0.10% of span
Frequency Response	3 db at 10Hz
Variations due to temp. change	± 0.01% of span °F
Variations due to voltage change	0.05% of span per volt
Ambient limits:	-20°F to 130°F
- C. I/P Converters:

Input signal	4-20mA
Output signal	3 to 15 psig
Accuracy	± 0.75% of span
Linearity	± 0.50% of span
Hysteresis	± 0.50% of span
Deadband	± 0.10% of span

- D. Rate/Reset Controllers: Use proportional type with adjustable integral and derivative actions. The controllers shall be field adjustable and provide a switch to eliminate the integral and derivative functions for calibration.
- E. Communications Ports: Provide all sensors and controllers with RS-232 serial communications port for the control network communication.

2.2 ELECTRONIC DEVICES FOR AIR HANDLING SYSTEMS

- A. Smoke Detectors: Specified to be furnished under Division 26 and mounted by Division 23. This Contractor shall install smoke detectors for HVAC systems where called for in sequence of operation, installed per NFPA, IBC, and/or local codes.
- B. Temperature sensors shall be Platinum, 1000 ohms nickel iron or RTDs, accurate to ±0.1% at 0°C.
- C. Space (room) Thermostats shall be surface mounted in decorator style non-vented plastic covers with digital temperature display. Thermostats shall have a tamper resistant cover with manual occupant adjustment to permit a ±3° deviation from the stored setpoint. Delete manual adjustment in non-occupied applications. Minimum range shall be 50°F to 95°F. Thermostats shall have an override button and green LED light to indicate when system is in the "Occupied" mode. Thermostats shall be "Wireless" as shown on the drawings. Wireless Thermostat operating range shall be a minimum of 200 feet and at least a 15-year AA battery life.
- D. Duct temperature thermostats shall be of the averaging type to cover the entire duct cross-section. Element casing shall be copper. Minimum range shall be 32°F to 110°F. Provide capillary mounting clips as required.
- E. Outdoor air temperature sensors shall be mounted in weatherproof box and protected by a ventilated sun shield that covers the sensor on all sides but below. Minimum range shall be -30°F to 200°F.
- F. Space (room) humidity transmitters shall be surface mounted in decorator style non-vented plastic covers. Sensors shall utilize resistance change of bulk polymer with ±2% RH accuracy at 77°F and temperature compensation. Minimum range shall be 0-100% RH.
- G. Outdoor Humidity Transmitters shall be mounted in a weatherproof box and protected by a ventilated sunshield which covers the sensor on all sides but below. Sensor shall utilize resistance change of bulk polymer with ±2% RH accuracy at 77°F and temperature compensation. Minimum range shall be 0-100% RH.
- H. Static air pressure transducers shall measure the differential pressure between the high and low ports on the transducer. They shall be accurate to within plus or minus one (1) percent of full scale and be capable of withstanding a momentary pressure of up to eight (8) times the rated pressure, or 8" W.G. whichever is greater without damage. The diaphragm shall be rated for use with air, between 32°F and 125°F.

- I. All automatic fluid flow control valves shall be fully proportional with modulating plugs for equal percentage or linear flow characteristics. Valve trim shall be suitable for chilled water, hot water, or steam service. The valve stem assembly shall be fashioned from high grade stainless steel. The automatic control valve shall be sized by the control manufacturer for the appropriate pressure drop, but no greater than 3 psi, to ensure proper throttling performance at all system loads. Provide 2-way or 3-way valves as shown on the equipment schedule or drawings. The valve body and actuator shall be sufficient to handle system pressure and shall close against the differential pressures liable to be encountered in the system. Body pressure rating and connection type construction shall be suitable for the service:
- J. Ball valves ½" through 2" shall be constructed with a cast brass body and screwed end.
- K. Vee-Ball valves 2" through 4" shall be constructed with a steel body and flanged or screwed connections.
- L. Butterfly valves 6" and above shall be constructed with a cast iron body and have flanged connections.
- M. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless steel stem shall be provided. Bonnet, cage, stem, and the plug assembly shall be removable for servicing.

2.3 ELECTRONIC DEVICES FOR HYDRONIC AND/OR GASEOUS SYSTEMS

- A. Temperature Transmitters shall have elements suitable for immersion into tanks and piping and have platinum RTD for use with bridge circuit controllers or transmitters. Sensors to be single, dual, averaging, dual wound or suitable to maintain stable control. Provide stainless steel immersion wells with heat conducting compound in tanks and piping. Minimum range shall be -30°F to 240°F.
- B. Differential Pressure Switch: Rate for 120V, 60Hz single-phase power. Provide switches equipped with adjustable setpoint, dust-tight enclosures and snap-acting contacts, housed in a NEMA 4 enclosure.
- C. Differential Pressure Transmitters shall be stainless steel with ceramic capacitive sensing element with temperature compensation. Sensor shall have overpressure rating three times the sensing range, 3,000 psi burst pressure, and housed in a splash-proof enclosure with gauge. Minimum range shall be 15 to 75 psi or 100 to 500 psi, as best meets system operation.
- D. Pressure Transmitters: Provide an electronic device with pressure ranges from -30" Hg to 400 psig that generates a 4 – 20 ma signal, suitable for gaseous or water applications. Device shall be housed in a watertight polystyrene enclosure. Device shall be suitable for temperature ranges of -12°F to 167°F. Device shall be provided with a pressure gauge in a corresponding pressure range.
- E. Stainless Steel Pressure Transmitter: Provide a stainless steel pressure transmitter with ranges from -30" Hg to 2000 psi, made of 304 stainless, suitable operating range from -40°F to 200°F, compatible with gases or liquids. Output will be 4-20 ma with 10-30 VDC supply voltage at 25 ma.
- F. Water Flow Switches: Provide stainless steel or bronze paddle switches. For chilled water, provide vapor-proof type to prevent condensation in the electrical switch. Provide pressure-flow switches of below-actuated mercury or snap-acting type with appropriate scale range and differential adjustment for service indicated.

- G. Water Flow Transmitters shall be turbine in-stream type with nickel-plated brass wetted components, electronic impedance sensing and 2% accuracy manufactured by Onicon. Device shall be fitted with hot tap adapter and proper stem length. Minimum range shall be 30° to 180°F.
- H. Liquid Level Transmitter: Provide electronic probe-type level control and monitoring sensor. Level sensors shall provide analog signal monitoring of tank liquid level.
- I. Condenser Water Conductivity Transmitter: Provide a sensor with a calibration range of 0 to 5,000 microns, 120V 60Hz, 2" MNPT pipe connection, 35°F to 100°F operating range.
- J. pH Transmitter: Provide a sensor with a range of 2 to 12pH, 120V 60Hz, 1" MNPT pipe connection, 35°F to 100°F operating range.

2.4 CONTROL DAMPERS

- A. Control dampers shall be multi-blade opposed-action type. Frames shall be formed 16-gauge galvanized steel channel with corner braces above size 20" wide and 20" high. Maximum individual damper width shall not exceed 48". Blades shall be 6" (maximum) wide, constructed of 16 U.S. Gauge (minimum thickness) formed galvanized steel attached to cold-rolled galvanized steel axles. Axle bearings shall be self-lubricating nylon or Teflon. Damper shall be controlled by factory assembled operating linkages concealed in the frame outside of airstream, constructed of galvanized steel. Individual actuators shall serve a maximum of 30 square feet of damper area. Provide additional actuators for larger areas. Ruskin CD35 or equal by Arrow United, Cesco, Greenheck, or National Controlled Air.
- B. Dampers opening to outdoors shall be provided with jamb seals and blade seals. Seals shall be provided for all control dampers with rated operating range from -40°F to 180°F. Jamb seals shall be stainless steel and blade seals shall be compressible neoprene, PVC-coated polyester fabric, synthetic elastomer, or extruded vinyl. Blade seals shall be replaceable. Leakage rate for dampers opening to outdoors shall not exceed 11 CFM per sq. ft. at 1" static pressure when measured in a 48" x 48" size. Leakage rate shall be AMCA certified. Ruskin CD36 or equal by Arrow United, Cesco, Greenheck, or National Controlled Air.
- C. Motorized Control Dampers to be installed by the mechanical contractor.

2.5 MISCELLANEOUS ELECTRONIC DEVICES

- A. Current switches shall be solid state switch with adjustable setpoint (set at no load condition for fan or pump run status). Switch capacity shall be selected based on motor monitored.
- B. Electric actuators shall either be push-pull magnetic or hydraulic type, or rotary (gear-train) type for two-position or modulating service as required by application. All electric actuators shall be UL listed with NEMA 1 enclosures, unless otherwise acceptable.
 - 1. Thermally powered (heat motor) actuators are not acceptable.
 - 2. Actuators shall fail to the position as indicated on the drawings.
 - 3. Actuators shall be permanently lubricated; gear-train units shall be oil-immersed type. Actuator housings shall be metal or plastic. Ambient temperature range shall be at least 40°F to 120°F, except actuators subjected to outdoor ambients shall have ambient range of -20°F to 130°F minimum. Actuator size and rating shall be suitable for intended application.
 - 4. Modulating magnetic or electric actuators with adjustable end switches to prevent overstroking are acceptable in sizes $\leq 1"$.
 - 5. Positive positioners shall be provided on actuators for AHU's control, to provide smooth modulation or proper sequencing:

- a. Positioner start-point shall be adjustable (or selectable).
 - b. Positioner span shall be adjustable, or at least three fixed spans for sequencing applications shall be available.
- C. Control Relays: Interposing control relays shall be rated for the application, have a minimum of two (2) sets of Form C contacts, and be enclosed in a dustproof enclosure. The coils shall be equipped with transient suppression devices to limit transients.
- D. Water detector shall use gold-plated probes mounted in an adjustable height watertight enclosure with N.O. and N.C. contacts.

2.6 COMMUNICATION

- A. This project shall be comprised of a high speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall be as defined below.
1. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/Zigbee (802.15.4) as defined by the Zigbee Standard.
 - a. Each communication interface shall be ANSI/ASHRAE Standard 135-2016 (BACnet®/ZigBee®).
 - b. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.
 - c. Wireless equipment controllers and auxiliary control devices shall conform to:
 - 1) IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.
 - 2) Communication between equipment controllers shall conform to ANSI/ASHRAE Standard 135-2016 (BACnet®/ZigBee®) standard as BACnet tunneling devices to accommodate future integration.
 - 3) Operating range shall be a minimum of 200 feet (60 m); open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.
 - 4) To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.
 - 5) Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.
 - 6) Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E
 2. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as defined by the BACnet standard.
 - a. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all controllers within the system.
- B. The Owner will provide all communication media, connectors, repeaters, network switches, and routers necessary for the high speed Ethernet network. An active Ethernet port will be provided adjacent to each System Controller and operator interface (PC) for connection to this high speed Ethernet network.

1. All values within the system – contained in both the system and unit controllers - (i.e. Schedules, Data Logs, Points, Application Variables, Custom Program Variables) shall be readable and controllable (where appropriate) by any System Controller or BACnet Workstation on the communications network via BACnet.

2.7

2.8 CONTROL PANELS

- A. All controllers, relays, switches, etc., for equipment located within equipment rooms shall be mounted in enclosed control panels with hinged locking doors. Indicating devices and switches shall be mounted on the face of the control panel door. All control devices, including indicators, for equipment located in exposed areas subject to outside weather conditions, shall be mounted inside weatherproof enclosures. Location of each panel is to be convenient for adjustment service. Name plates shall be provided beneath each panel-mounted control device describing the function of the device.
- B. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.
- C. All enclosures shall be fully enclosed cabinets with 12-gauge, furniture steel construction with baked enamel finish and hinged key door locks and shall have removable face and back panels. Panels shall be Underwriters Laboratories, Inc. listed for line voltage applications.
- D. All panels will be documented with schematics, parts layout, parts listing, component and board identifiers consistent on all documentation, theory of operation and service manuals.
- E. Mount panels adjacent to associated equipment on vibration free walls or free standing steel angle supports.

2.9 GENERAL PRODUCT DESCRIPTION

- A. The Building Automation System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, fire management, lighting control, information management, and historical data collection and archiving.
- B. The facility management system shall consist of the following:
 1. Standalone DDC panels.
 2. Application specific controllers (ASPs).
 3. Remote Display Devices.
 4. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.
 5. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
 6. Standalone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device, such as a central file server.

2.10 NETWORKING/COMMUNICATIONS (LOCAL NETWORK)

The design of the BAS shall be networked. Inherent in the system's design shall be the ability to expand or modify the network via a local network.

A. Local Network:

1. Personal Computer/Panel Support: The Personal Computer or Digital Panel shall directly oversee a local network such that communications may be executed directly to and between ASCs. The Personal Computer version and Digital Panel version shall be referred to as the "Digital Panel(s)" throughout this document.
2. Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data on the network. Access to system data shall not be restricted by the hardware configuration of the facility management system.
3. Global Data Sharing: Global Data Sharing or Global point broadcasting shall allow point data to be shared between ASCs, when it would be inefficient or impractical to locate multiple sensors.
4. General Network Design: Network design shall include the following provisions:
 - a. Data transfer rates for alarm reporting and quick point status from multiple ASCs. The minimum baud rate shall be 9600 baud.
 - b. Support of any combination of ASCs. A minimum of 100 ASCs shall be supported on a single local network. The bus shall be addressable for up to 255 ASCs.
 - c. Detection of single or multiple failures of ASCs or the network media.
 - d. Error detection, correction, and retransmission to guarantee data integrity.
 - e. Commonly available, multiple-sourced, networking components shall be used.
 - f. Use of an industry standard protocol, such as Optomux, and IEEE RS-485 communications interface.

2.11 NETWORKING/COMMUNICATIONS (LOCAL AREA NETWORK)

The design of the BAS shall network operator workstations and Standalone DDC panels. Inherent in the system's design shall be the ability to expand or modify the network.

A. Local Area Network:

1. Panel Support: DDC panels shall directly reside on a single shared high speed local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
2. Dynamic Data Access: All operator devices, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.
3. Access to system data shall not be restricted by the hardware configuration of the facility management system. The hardware configuration of the FMS network shall be transparent to the user when accessing data or developing control programs.
4. General Network Design: Network design shall include the following provisions:
 - a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices. The minimum baud rate shall be 1 Megabaud.
 - b. Support of any combination of controllers and Operator Workstations directly connected to the local area network.

- c. Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
- d. Message and alarm buffering to prevent information from being lost.
- e. Error detection, correction, and re-transmission to guarantee data integrity.
- f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
- g. Commonly available, multiple sourced, networking components shall be used to allow the FMS to coexist with other networking applications. The following are acceptable technologies: ETHERNET.

2.12 DDC PANELS

- A. General: Digital Panels shall be microprocessor-based, multi-tasking, multi-user, digital control processors.
- B. Memory: Each Digital Panel shall have sufficient memory to support its own operating system and data bases including:
 - 1. Control processes.
 - 2. Energy Management Applications.
 - 3. Alarm Management.
 - 4. Trend Data.
 - 5. Maintenance Support Applications.
 - 6. Operator I/O.
 - 7. Manual Override Monitoring.
- C. Expandability: The system shall be modular in nature and shall permit easy expansion through the addition of field controllers, sensors, and actuators.
- D. Serial Communication Parts: Digital Panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices, such as laptop computers, Personal Computers, and Video Display terminals.
- E. Hardware Override Monitoring: Digital Panels shall monitor the status of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited.
- F. Integrated On-Line Diagnostics: Each Digital Panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. Digital Panels shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Digital Panel.
- G. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.
- H. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of the Digital Panel to prevent the loss of data base or operating system software:
 - 1. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

2. Upon restoration of normal power, the Digital Panel shall automatically resume full operation without manual intervention.

2.13 STANDALONE DDC PANELS

- A. General: Standalone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and the attached point list.
- B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases including:
 1. Control Processes.
 2. Energy Management Applications.
 3. Alarm Management.
 4. Historical/Trend Data for all points.
 5. Maintenance Support Applications.
 6. Custom Processes.
 7. Operator I/O.
 8. Manual Override Monitoring.
- C. Point types: Each DDC panel shall support the following types of point inputs and outputs:
 1. Digital Inputs for status/alarm contacts.
 2. Digital Outputs for on/off equipment control
 3. Analog Inputs for temperature, pressure, humidity, flow and position measurements
 4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
 5. Pulse Inputs for pulsed contact monitoring
- D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators. The system architecture shall support 25% expansion capacity of all types of DDC panels, and all point types included in the initial installation.
- E. Serial Communication Ports: Standalone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel Operator's Terminals. Standalone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.
- F. Hardware Override Switches: As indicated in the point schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, onboard hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.
- G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides, and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.

- H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
- I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel and shall not require the connection of an operator I/O device.
- J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients.
- K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical controller configuration data, and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention. Should DDC panel memory be lost for any reason, the panel will automatically receive a download via the local area network, phone lines, or connected computer. In addition, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port, or via telephone line dial-in.

2.14 SYSTEM SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system, as described in this specification, shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the Digital Panel and shall not be dependent upon any higher-level computer for execution.

B. Control Software Description:

1. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one-hour period.
2. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

C. Energy Management Applications: Digital Panels shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling.
2. Calendar Based Scheduling.
3. Holiday Scheduling.
4. Optimal Start.
5. Optimal Stop.
6. Demand Limiting.
7. Load Rolling.
8. Heating/Cooling Interlock.

D. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment described in the "Execution" portion of this specification.

- E. Programming Capability: Digital Panels shall be able to execute configured processes defined by the user to automatically perform calculations and control routines.
- F. Process Inputs and Variables: It shall be possible to use any of the following in a configured process:
 - 1. Any system-measured point data or status.
 - 2. Any calculated data.
 - 3. Any results from other processes.
 - 4. Boolean logic operators (and, or).
- G. Process Triggers: Configured processes may be triggered based on any combination of the following:
 - 1. Time of day.
 - 2. Calendar date.
 - 3. Other processes.
 - 4. Events (e.g., point alarms).
- H. Data Access: A single process shall be able to incorporate measured or calculated data from any and all other ASCs. In addition, a single process shall be able to issue commands to points in any and all other ASCs on the local network.
- I. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each Digital Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the Digital Panel's ability to report alarms be affected by either operator activity at the local I/O device, or communications with other ASCs on the network:
- J. Point Change Report Description: All alarm or point change reports shall include the points' English language description, and the time and date of occurrence.
- K. Prioritizing: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Users shall have the ability to manually inhibit alarm reporting for each point. The user shall also be able to define conditions under which point changes need to be acknowledged by an operator, and/or logged for analysis at a later date.
- L. Report Routing: Alarm reports and messages shall be directed to an operator device.
- M. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 60-character alarm message to more fully describe the alarm condition or direct operator response. Each Digital Panel shall be capable of storing a library of at least 100 Alarm Messages. Each message may be assignable to any number of points in the panel.
- N. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until a manual request is received, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

- O. Trend Analysis: A data collection utility shall be provided to automatically sample, store, and display system data. Measured and calculated analog and binary data shall be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 24 hours, in one-minute or one-hour intervals, shall be provided. Each Digital Panel shall have a dedicated buffer for trend data, and shall be capable of storing 16 trend logs. Each trend log shall have up to four points trended at 48 data samples each. Data shall be sorted at the Digital Panel, and uploaded to floppy disk storage when archival is desired.
- P. Runtime Totalization: Digital Panels shall automatically accumulate and store runtime hours for binary input and output points specified in the "Execution" portion of this specification.
 - 1. The Totalization routine shall have a sampling resolution of one minute.
 - 2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.
- Q. Pulse Totalization: Digital Panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points:
 - 1. Totalization shall provide calculation and storage accumulations of up to 9,999,999 units (e.g. KWH, gallons, KBtu, tons, etc.).
 - 2. The Totalization routine shall have a sampling resolution of one minute.
 - 3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.
 - 4. The information available from the Pulse Totalization shall include, but not be limited to, the following:
 - a. Peak Demand, with date and time stamp.
 - b. 24-hour Demand Log.
 - c. Accumulated KWH for day.
 - d. Sunday through Saturday KWH usage.
 - e. Sunday through Saturday Demand KW.
 - f. Demand KW annual history for past 12 periods.
 - g. KWH annual history for past 12 periods.
- R. Event Totalization: Digital Panels shall have the ability to count events, such as the number of times a pump or fan system is cycled on and off:
 - 1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
 - 2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.15 OPERATOR INTERFACE

- A. dedicated PC shall not be required to access the Enterprise or Building operator web interfaces.
- B. All BAS connected workstations shall function in a true multi-user, multi-tasking environment:
 - 1. All terminals can access the same network at the same time.
 - 2. All terminals can access and/or control the same DCU at the same time.
 - 3. All terminals can access and/or modify the same database at the same time.
 - 4. All terminals shall be able to archive data, alarms, and network actions to hard disk regardless of what application programs are being currently executed (i.e., LAN operating system, word processing, etc.). All archiving disk traffic shall be accomplished on-line without effecting the operation of the current programs.

- C. Additional on-line functions, supported concurrently in every workstation without rebooting, shall include, but not limited to:
1. On-line database development and editing.
 2. On-line BAS implementation and tuning.
 3. On-line graphics development.
 4. Real time facility control.

2.16 FRONT END GRAPHICS

- A. The BAS contractor shall provide all the necessary hardware, data, information, and graphical images for the DDC system to publish fully interactive web-page graphics for monitoring and operating the DDC system's controllers using only a standard web browser. Support for both Microsoft Internet Explorer and Netscape Navigator must be provided.
- B. The contractor shall include developed graphics for each piece of equipment being controlled and/or monitored by the BAS. BAS graphics will include the following screen pages as a minimum, but not limited to:
1. System Pages:
 - a. Initial Screen. Provide building address and links to system screens on a scanned-in background of the building front elevation. Elevation will be from an architectural rendering or photograph. Links will be provided to each floor plan and as applicable, each mechanical chiller plant, electrical monitoring system and fuel monitoring systems.
 - b. Building floor plan layouts will show every room. Where temperature and humidity sensors are installed in the building, show readings on the floor plan. Show all equipment including chillers, WSHPs, Cooling Towers, Boilers, Pumps, etc. Provide links to each piece of equipment and to system pages.
 - c. Chillers: Show all information for the chiller(s) on a single page. Show high and low alarm limits for each item. Provide links to condenser and chilled water pages. Layout of the chiller pages will resemble the equipment layout in the building. Leave and identify spaces for future equipment as shown in the construction drawings.

PART 3: EXECUTION

3.1 EXAMINATION

- A. The Contract Documents shall be thoroughly examined for coordination of control devices, their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- B. The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

3.2 EXISTING EQUIPMENT

- A. Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified in writing.

3.3 WIRING

- A. All electrical wire, conduit, cable, fittings, junction boxes, connectors, etc., associated with the systems, including interlock wiring, shall be furnished and installed complete under these specifications.
- B. Installation shall be in accordance with the requirements of Division 26, the National Electrical Code and local codes. All electrical work included under this section shall be complete with labor, materials and installations.
- C. Run all wiring and conduit concealed unless conditions do not allow. Secure approval from Engineer prior to installing surface raceway. Where surface raceway is required, it shall be wire mold or approved equal.
- D. All control wiring routed in conduit shall not have any other type of wiring (power, etc.) routed in the same conduit.
- E. Where required for electronic controls or interfacing, provide relays and other devices with low impedance contacts. Where required to maintain proper relay operation and prevent chatter, increase minimum control wire gauges specified herein.
- F. All line voltage electrical wiring shall be enclosed in conduit. All exposed low voltage electrical wiring shall be installed in conduit or EMT. All low voltage wiring located above ceilings in plenums shall be 25/50 flame spread/smoke developed rated and UL listed. Support wiring 24" OC by clips to structure.
- G. For control systems, all wiring will be manufactured by Beldon or equal. Cabling for pulse demand meter shall be as manufactured by Beldon or equal. Provide cable in accordance with manufacturer's recommendations.

3.4 INSTALLATION REQUIREMENTS

- A. Any panels associated with the control system shall be furnished and installed under this section of the work. Connected to numbered terminal strips shall terminate panel wiring. Wire nut connections shall not be allowed.
- B. All devices, panels, etc. furnished and/or installed shall be located where they can be calibrated and maintained from the floor without use of a ladder. These items shall be identified by means of plates made of plastic, suitably engraved, embossed or punched.
- C. Any conduit on roof shall be at an absolute minimum and shall have prior written approval.
- D. All conduit and fittings used indoors and outdoors shall be metal to minimize corrosion and moisture entry.

3.5 LOCATING DDC PANELS

- A. In order to minimize wiring costs, DDC panels should be installed near equipment or systems, which are to be monitored and/or controlled. Panels located in administrative, common areas, or equipment aisles will be recessed mounted. Panels mounted in electrical or mechanical rooms will be surface mounted.
- B. Consider providing sub-unit controllers or I/O expansion units near each cluster of sensor/actuator points, with sub-unit controllers and I/O expansion units reporting to the stand-alone controllers. Where practical, Application Specific Controllers or stand-alone controllers should be installed in mechanical equipment rooms.

- C. All PC boards enclosed in metal boxes shall be mounted to a non-conductive, non-metallic surface to avoid shorting or grounding.

3.6 POWER/ENVIRONMENT/SPACE REQUIREMENTS

- A. The environmental conditions in the space in which the stand-alone controllers and associated equipment are located shall meet the manufacturer's requirements of 30°F to 120°F and 5% RH to 95% RH.
- B. Provide adequate space in front of the equipment for easy access and repairs. Provide adequate lighting over all DDC equipment and panels enclosing interfacing devices.

3.7 CONTROL SYSTEM CHECKOUT AND TESTING

- A. Start-up testing. All testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - 1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all of the instruments, controls, and accessory equipment furnished under this specification.
 - 2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - 3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturer's recommendations.
 - 4. Verify all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starter, etc.) operate properly and normal positions are correct.
 - 5. Verify all analog output devices (I/Ps, actuators, etc) are functional, that start and end are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
 - 6. Verify the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimal start/stop routines.
 - 7. Alarms and Interlocks
 - a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction,
 - c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.8 OPERATOR INSTRUCTION AND TRAINING

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

- B. At a time mutually agreed upon during system commissioning as stated above, BAS contractor shall give 4 hours of instructions to the Owner's designated personnel on the operation of all central processing and peripherals and describe intended use with respect to the programmed functions specified. Operator orientation of the FMS shall include, but not be limited to, the overall operational program, equipment functions (both individually and as part of the total integrated system), commands, advisories, and appropriate operator intervention required in responding to the system's operation. An Owner's Manual, prepared for this project by the BAS contractor, shall be used in addition to the instruction. Two (2) copies of the Owner's Manual shall be provided.
- C. Four hours of additional instruction by the BAS contractor shall be provided to the Owner's designated personnel. This instruction shall provide a description of the chronological information flow from field sensors, contacts and devices to the centrally located system. The overview of the system's communication network shall be to provide a better understanding to the operator of the interplay between initiating devices, field processing units, system communications, and their importance within the operating system.

END OF SECTION 23 0923

**SECTION 23 2000
PIPE, FITTINGS AND ACCESSORIES – HVAC**

PART 1: GENERAL

1.1 DESCRIPTION

- A. Piping specified in this Section is for types of pipe and accessories used in Division 23.

1.2 RELATED SECTION

- A. Section 23 0500 Common Work Results for HVAC.

1.3 QUALITY ASSURANCE

- A. Pressure piping systems shall meet requirements of the ASME and ANSI Standards B31.1 Power Piping and B31.9 Building Services Piping, and all addenda.
- B. Codes and regulations referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes and regulations, the drawings and specifications govern.
- C. Pressure/temperature ratings of all components and accessories shall meet or exceed design conditions for the system in which they are installed.
- D. Welding shall be in accordance with procedures of the National Certified Pipe Welding Bureau and shall comply with the requirements of the ANSI Code for Pressure Piping. Welders shall be qualified under the above procedures and certified by the National Certified Pipe Welding Bureau.

PART 2: PRODUCTS

2.1 PIPE AND FITTINGS

- A. Steel Piping:

1. Pipe (up to 12" diameter):

<u>Material</u>	<u>Specification</u>
Schedule 40 Black steel	ASTM A53-97b Grade B
Schedule 80 Black steel	ASTM A53-97b Grade B
Schedule 40 Galvanized steel	ASTM A53-97b

2. Fittings:

- a. 150 lb. SWP malleable iron screwed fittings conforming to ANSI B16.3.
- b. 125 lb. SWP cast iron flange fittings conforming to ANSI B16.1.
- c. Standard weight factory fabricated butt-welding fittings conforming to ANSI B16.9 and ASTM A234.
- d. 150 lb. forged steel welding neck or flat face slip-on flanges conforming to ASTM A181.
- e. Socket fittings conforming to ANSI B16.11.
- f. Cast iron drainage pattern fittings conforming to ANSI B16.12.
- g. Dielectric couplings and/or flange kits shall be provided at connections between ferrous and non-ferrous pipe. Provide with high temperature gaskets rated for 300°F steam service.

- h. Unions:
 - 1) Except where otherwise specified, unions in welded piping shall be flanges.
 - 2) Unions in piping 2" and smaller shall be 150 lb. malleable iron, ground joint, bronze to iron, screw type.
 - 3) Unions in screwed piping 2½" and larger shall be 125 lb. cast iron flanges.
- i. Fittings, flanges, and unions in galvanized steel pipe shall be galvanized.

3. Joints, unless specified otherwise:

- a. Screwed Joints: Joint compound shall be "Tite-Seal" or Teflon tape, except where otherwise specified.
- b. Welded Joints: Welding rods shall be compatible with the material to be welded. Welding shall be by electric arc or oxyacetylene methods.
- c. Flanged joints shall be made up with 1/16" thick, ring type, compressed composition sheet gasket, except for gas piping which shall be made up with aluminum "O" ring type gaskets. Flange bolts shall be steel hexagon head type, conforming to ASTM A307. Nuts shall conform to ASTM A193.

B. Copper Piping:

1. Pipe:

<u>Material</u>	<u>Specification</u>
Type L tube	ASTM B88-99
Type K tube	ASTM B88-99

2. Fittings:

- a. Wrought copper solder joint type conforming to ANSI B16.22. Cast fittings conforming to ANSI B16.18, except where otherwise specified, may be used only in patterns not available in wrought fittings, and where desired changes in direction and/or reduction in size cannot be accomplished with two wrought fittings.
- b. Adapter fittings shall be provided at all copper to brass pipe connections. Adapters 2" and smaller shall be cast bronze or wrought copper. Adapters larger than 2" shall be 150 lb. cast bronze flanges. Adapters between the meter and the pressure reducing valve shall be 250 lb. cast bronze flanges.
- c. 150 lb. cast bronze flange fittings conforming to ANSI B16.24 downstream of the pressure reducing valves.
- d. Dielectric couplings and/or flanged kits shall be provided at all copper to steel pipe connections.
- e. Unions:
 - 1) Except where otherwise specified, unions shall be wrought copper or cast bronze.
 - 2) Unions in piping 2½" and larger shall be 150 lb. cast bronze flanges, downstream of the pressure reducing valve and 250 lb. between the meter and the PRV.
 - 3) Insulating unions shall be provided at all equipment having ferrous connections.

3. Joints, unless specified otherwise:
- a. Solder Joints: Solder shall be 95/5 (95% tin, 5% antimony) except where otherwise specified. Where specified or noted on the drawings, solder shall have a silver alloy solder having a melting point of not less than 1100°F. NO LEAD SOLDER SHALL BE PERMITTED.
 - b. Solder flux shall be the type recommended by the manufacturer of the 95/5 solder used, meeting NSF/ANSI 61. Silver brazing flux shall be used for solder of 1100°F. or higher melting point.

4. Steel Pipe (up to 12" diameter):

<u>Material</u>	<u>Specification</u>
Schedule 40 Black steel	ASTM A53-97b Grade B

5. Steel Fittings:

- a. Ductile iron fittings, conforming to ASTM A536; forged steel, conforming to ASTM A234; or fabricated from carbon steel pipe, conforming to ASTM A53 with grooved ends in accordance with AWWA C606.
- b. Couplings for use with grooved end fittings shall consist of ductile iron housings, conforming to ASTM A536, complete with pressure responsive synthetic rubber gasket. (Grade to suit the intended service.)
 - 1) Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9.
 - 2) Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings shall be placed in close proximity to the vibration source.
 - 3) Dielectric waterways shall be provided at connections between ferrous and non-ferrous pipe. Dielectric waterways shall consist of ductile iron or carbon steel body, zinc electroplated, with LTHS high temperature stabilized polyolefin polymer liner.
 - 4) Where grooved joint piping systems are utilized, unions are not required. Couplings shall serve as unions.

6. Copper Pipe:

<u>Material</u>	<u>Specification</u>
Type L tube	ASTM B88-99
Type K tube	ASTM B88-99

7. Copper Fittings:

- a. Grooved joint fittings for use with copper tubing shall be wrought copper conforming to ANSI B16.22 or bronze sand cast fittings conforming to ANSI B16.18 with copper tube dimensioned grooved ends. (Flaring of tube and fitting ends to IPS dimensions is not allowed.)
 - 1) Couplings for use with grooved joint fittings shall consist of ductile iron housings, coated with copper colored alkyd enamel, grade to suit the intended service.
 - 2) Where grooved joint piping systems are utilized, unions are not required. Couplings shall serve as unions.

2.2 SLEEVES

- A. Provide standard weight steel pipe sleeves at all points where piping passes through walls, floors and ceilings, except where otherwise specified.
- B. #20 U.S. gauge galvanized steel sleeves may be used through all walls and through floors in concealed pipe chases where concrete thickness is 4" or less.

PART 3: EXECUTION

3.1 PIPING – GENERAL

- A. All piping shall be run straight and parallel to building construction. All changes in directions shall be made with fittings as specified herein and shown on the drawings.
- B. Pipe connections to equipment which is supported independent of the pipe, including pumps, shall be aligned with the equipment.
- C. Install piping so as to preserve access to all valves, air vents, and other equipment and to provide the maximum headroom possible.
- D. All piping, except cast iron, which runs through concrete slabs or walls shall be insulated or caulked in sleeves as hereinafter specified so that the pipe metal does not come in contact with the concrete masonry.
- E. Equipment Drains, Drips, Etc.:
 - 1. All devices and equipment having drain, drip or blowdown connection shall be piped to nearest floor drain terminating with an elbow over grate, except where otherwise specified.
 - 2. Piping shall be run parallel and plumb to walls and shall be braced to walls, floor, other piping or equipment.
 - 3. Piping shall be full size of device or equipment connection. Except for relief valve discharges, horizontal drains may be combined into one pipe that is one pipe larger than largest connecting pipe.
 - 4. Condensate drains shall be trapped and provided with unions and cleanouts.
- F. Unions shall be provided at all connections to flow control valves, equipment and apparatus.

3.2 PROCEDURES FOR PIPE JOINTS

- A. Welded Joints:
 - 1. All welding of pipe shall conform to the ASME and ANSI Standards B31.1 Power Piping and B31.9 Building Services Piping.
 - 2. Mitering or notching pipe to form elbows and tees will not be permitted. Field and shop bevels shall be in accordance with the recognized standards and shall be done by mechanical means or flame cutting. Where beveling is done by flame cutting, surfaces shall be cleaned of slag, scale and oxidation prior to welding.
 - 3. Before welding, the component parts to be welded shall be aligned so no strain is placed on the weld when finally positioned. Height shall be aligned so that no part of the pipe wall is offset by more than 20 percent of the wall thickness. Flanges and branches shall be set true. This alignment shall be preserved during the welding operations. Connections larger than 6" shall be made with backing rings at welds.

4. Where the temperature of the component parts being welded reaches 32°F or lower, the material shall be heated to approximately 100°F for a distance of 3' on each side of the weld before welding, and the weld shall be finished before the material cools to 32°F. All welds shall be full penetration welds.
 5. Defective welds shall be removed and replaced at no additional cost to the Owner. Repairing of defective welds by adding new materials over the defects or by peening will not be permitted.
 6. Electrodes shall be stored in a dry, heated area and shall be kept free of moisture or dampness during fabrication operations. Electrodes that have lost part of their flux shall be discarded.
 7. Fire protection safeguards shall be employed in connection with welding operations.
 8. No welding will be permitted where communication equipment has been installed.
 9. Before any welder shall perform any pipe welding, submit a copy of the Welding Operator Qualification Test as required by the referenced standards cited hereinbefore.
- B. Screwed Joints:
1. All threads shall be standard, clean cut and tapered. All burrs shall be reamed from inside of the pipe and pipe shall be turned on end and all loose dirt and scale knocked out.
 2. Pipes with threads stripped, chipped or damaged, or split pipe or defective fittings shall not be used.
 3. Joint compound shall be applied to the male threads only.
- C. Flanged Joints: Gaskets shall extend to inside the bolt holes, and flanges shall be brought up truly and water and air tight on gaskets by tightening bolts on opposite sides of the pipe.
- D. Copper Tubing Solder Joints:
1. Ends of pipe shall be cut square and cleaned with sand cloth so as to remove all oxides before soldering. Fittings shall be similarly cleaned with sand cloth or wire brush.
 2. Flux shall be evenly applied to both pipe end and fittings.
 3. Solder shall completely fill all parts of joint. Clean excess flux from pipe after joint completed.

3.3 SLEEVES

- A. Provide all sleeves in floors, beams, walls, roof, etc., as required for installing work of this Division unless otherwise specified hereinafter.
- B. Where exposed in rooms, sleeves in floor slabs, except those on grade, shall project ¼" to 3/8" above finished floor.
- C. Sleeves shall be of sufficient size for pipe and full-size insulation to pass through.
- D. Sleeves through outside walls above grade shall be caulked watertight between pipe or pipe insulation and sleeve with lead and oakum.
- E. Pipes penetrating walls below grade shall be sealed with a waterproof, modular, mechanical expansion seal consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Sizing of links and wall sleeve shall be determined by manufacturer. GPT "Link-Seal" or Metraflex "MetraSeal".
- F. Sleeves through poured concrete shall be secured to the forms before concrete is poured.

- G. Piping passing under or through wall footings, foundations and retaining walls shall be provided with a relieving arc, or an iron pipe sleeve two pipe sizes greater than the pipe passing through.
- H. Sleeves shall be spaced sufficient distance from adjacent walls and other sleeves so that insulation and/or finish plates may be installed without cutting insulation or plates.
- I. Sleeves shall be placed on the piping as it is installed to permit installation of sleeves in walls, partitions, and slabs in one piece.
- J. See Section 23 0500 regarding firestop requirements.

3.4 PRESSURE TESTING

- A. See particular piping section for pressure testing requirements.

END OF SECTION 23 2000

**SECTION 23 2113
HYDRONIC PIPING**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the piping component types and other requirements for the hydronic piping associated with the mechanical systems.
- B. Hydronic water piping shall connect heat transfer equipment, pumps, components, and accessories to form a complete and operable system.

1.2 RELATED SECTIONS

- A. Section 23 0500 Common Work Results for HVAC
- B. Section 23 0523 HVAC Valves and Strainers
- C. Section 23 2000 Pipe, Fittings, and Accessories - HVAC
- D. Section 23 2114 Hydronic Specialties
- E. Section 23 2515 Glycol Freeze Protection

1.3 SYSTEM CONDITIONS

- A. The chilled water system shall be installed for the following conditions:

Design Pressure: 125 psig.
Working Pressure: _____ psig.
Operating Temperature Range: 40°F to 80°F.

- B. The condenser (cooling tower) water system shall be installed for the following conditions:

Design Pressure: 125 psig.
Working Pressure: _____ psig.
Operating Temperature Range: 35°F to 100°F.

- C. The tempered water system shall be installed for the following conditions:

Design Pressure: 125 psig.
Working Pressure: _____ psig.
Operating Temperature Range: 50°F to 200°F.

- D. The hot water heating system shall be installed for the following conditions:

Design Pressure: 125 psig.
Working Pressure: _____ psig.
Operating Temperature Range: 70°F to 200°F.

- E. The glycol system shall be installed for the following conditions:

Design Pressure: 125 psig.
Working Pressure: _____ psig.
Operating Temperature Range: 20°F to 200°F.

PART 2: PRODUCTS

2.1 PIPE

- A. Chilled Water Black Steel Schedule 40
1. Copper piping shall be used in lieu of steel for sizes 2" and smaller.
 2. Victaulic piping may be used in lieu of welded or threaded piping at the contractor's option,
- B. Condenser (Cooling Tower) Water Black Steel Schedule 40
1. Copper piping may be used in lieu of steel at the contractor's option for sizes 2" and smaller.
 2. Victaulic piping may be used in lieu of welded or threaded piping at the contractor's option.
- C. Tempered Water Black Steel Schedule 40
1. Copper piping may be used in lieu of steel at the contractor's option for sizes 2" and smaller.
 2. Victaulic piping may be used in lieu of welded or threaded piping at the contractor's option,
- D. Heating Hot Water Black Steel Schedule 40
1. Copper piping shall be used in lieu of steel for sizes 2" and smaller.
- E. Glycol Black Steel Schedule 40
1. Copper piping may be used in lieu of steel at the contractor's option for sizes 2" and smaller.
- F. Strainer Blowdown, Drains, and Relief Valve Discharge Galvanized Steel Schedule 40
1. Copper piping may be used in lieu of steel at the contractor's option for sizes 2" and smaller.

2.2 FITTINGS AND JOINTS

- A. Black steel piping 2½" and larger shall be butt welded.
- B. Black steel piping smaller than 2½" shall be screwed.
- C. Galvanized steel piping shall be screwed.
- D. Copper piping shall be brazed.

2.3 VALVES

- A. Chilled water valves:
1. Valves 2½" and larger shall be gate or butterfly type, except where otherwise indicated. Balancing valves, where shown, shall be plug valves.
 2. Valves smaller than 2½" shall be gate, globe, plug, and ball types as shown on the plans.
- B. Condenser water valves:

1. Valves 2½" and larger shall be butterfly type except where otherwise specified.
 2. Valves smaller than 2½" shall be gate, globe, and angle types.
- C. Tempered water valves:
1. Valves 2½" and larger shall be gate or butterfly type, except where otherwise indicated. Balancing valves, where shown, shall be plug valves.
 2. Valves smaller than 2½" shall be gate, globe, plug, and ball types as shown on the plans.
- D. Hot water heating valves:
1. Valves shall be gate, globe, and angle types except where otherwise indicated.
- E. Glycol valves:
1. Valves 2½" and larger shall be gate or butterfly type, except where otherwise indicated. Balancing valves, where shown, shall be plug valves.
 2. Valves smaller than 2½" shall be gate, globe, plug, and ball types as shown on the plans.
- 2.4 PIPE REDUCERS
- A. Eccentric type and concentric type.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Install pipe to slope upward in the direction of flow, 1" in 40'.
- B. Install reducers so as to eliminate unvented high points. Use eccentric reducers on horizontal pipe with flat side on top.
- C. Install interconnecting piping for apparatus and equipment.
- D. Exercise care to prevent dirt and foreign matter from entering system. All piping ends shall be capped during construction.

3.2 CLEANING OF PIPING SYSTEM

- A. Piping systems shall be cleaned prior to connection to an existing system (if applicable) and prior to the application of water treatment. Clean all piping systems with a degreaser as recommended by the chemical treatment supplier. Flush piping completely after cleaning.
- B. Equipment and systems shall be operated only for testing prior to the application of water treatment.
- C. Remove strainer baskets, clean, and reinstall.
- D. After operation of the system, remove strainer baskets, clean, and reinstall.

3.3 PIPE PRESSURE TEST

- A. Pressure test piping before insulating or concealing. During the test, hammer tap test each weld. Pipe shall hold the test pressure without perceptible leakage or pressure loss. Test piping at not less than 1½ times working pressure, but not greater than design pressure for two hours. Isolate equipment and apparatus that may be damaged during pressure test.

3.4 MAKE-UP

- A. Install make-up connection as detailed.

END OF SECTION 23 2113

**SECTION 23 2114
HYDRONIC SPECIALTIES**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This Section specifies the hydronic system specialty equipment requirements.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 0500 Common Work Results for HVAC
- C. Section 23 0700 Mechanical Systems Insulation
- D. Section 23 2000 Pipe, Fittings, and Accessories - HVAC
- E. Section 23 2113 Hydronic Piping

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide product data showing equipment dimensions, capacity, weight, pressure rating with associated Code compliance, and pipe connection sizes and locations.
- C. Provide manufacturer's instructions, indicate installation and support requirements.
- D. Provide operation and maintenance data; include start-up instructions, assembly drawings and parts list.

1.4 QUALITY ASSURANCE

- A. Except where otherwise specified, water specialties shall be Bell & Gossett, Dunham-Bush, or Thrush.

PART 2: PRODUCTS

2.1 AUTOMATIC AIR VENTS

- A. Air vents shall be rated for not less than 125 psig working pressure at maximum operating temperature of 250°F. Vents shall be Bell & Gossett #78 or equivalent by Maid-O-Mist or Taco.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Expansion tanks shall be installed as shown on the drawings.
- B. Air elimination fittings, makeup connections, and expansion tanks shall be interconnected as indicated on the drawings on the suction side of the circulating pump.

- C. Extend automatic air vent discharge pipe to floor drain, air conditioning unit drain pan, or as shown on the drawings.

END OF SECTION 23 2114

**SECTION 23 2124
PUMPS - END SUCTION**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements for base mounted end suction pumps and their motors.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 0100 Operation and Maintenance of HVAC Systems
- C. Section 23 0500 Common Work Results for HVAC
- D. Section 23 0700 Mechanical Systems Insulation

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide product data showing pump curve with system operating point, motor horsepower, electrical requirements, and rpm.
- C. Provide shop drawings showing pump dimensions and pipe connection size and accessories.
- D. Provide manufacturer's instructions; indicate installation and support requirements.
- E. Provide operation and maintenance procedures; include start-up instructions, assembly drawings and parts list.

1.4 QUALITY ASSURANCE

- A. Select pumps for quiet operation and system conditions. Impeller diameter shall not be larger than 85% of the casing inside diameter measured from the water cut-off point.
- B. Pump efficiency shall not be less than the level scheduled on the plans.
- C. Pump required net positive suction head shall not exceed 12', unless otherwise noted.
- D. Pumps shall be rated for operation at 215°F and 175 psi working pressure, unless otherwise noted.
- E. Pumps shall be selected so that motor will not overload to 125% of rated gpm.

PART 2: PRODUCTS

2.1 PUMPS – END SUCTION

- A. End suction single stage horizontal, base mounted, bronze fitted, except as noted below. Pump shall be Bell and Gossett Series 1510, Patterson Pro series, Armstrong Series 4030, Aurora 340 Series, or Peerless Type F.

2.2 CONSTRUCTION

- A. Base: Cast iron or fabricated steel, factory primed and finish painted with drip pan.
- B. Casing: Cast iron vertically split with vent plug and drain plug.
- C. Bearings: Ball type, external bracket mounted, greasable with fitting, selected for B-10 rating of 100,000 hours.
- D. Shaft: Stainless steel.
- E. Seal: Mechanical type, selected for the service encountered. Where external seal flushing line is used, a flush line filter shall be factory installed, selected for the pump head required.
- F. Shaft Sleeve: Bronze.
- G. Impeller: Bronze ASTM B119.
- H. Case Wearing Rings: Renewable bronze ASTM B62-4A.
- I. Coupling: Flexible type with shaft keys and guard.
- J. Motors: NEMA Type B, open drip-proof, high efficiency type as specified in Section 23 0500 Common Work Results for HVAC. If inverter duty motors are required, see Section 23 0500 for grounding ring requirements.

PART 3: EXECUTION

3.1 GENERAL

- A. Check pump shaft alignment prior to starting pump.
- B. Provide cocks on vents and valves on drains. Pipe drip pans to floor drains.
- C. Provide one (1) set of spare seals for each pump.
- D. Bolt pumps to concrete base and grout in place.

END OF SECTION 23 2124

**SECTION 23 3100
DUCTWORK**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the sheetmetal requirements for Division 23 ductwork.

1.2 RELATED SECTIONS

- A. Section 23 0500 Common Work Results for HVAC
- B. Section 23 0700 Mechanical Systems Insulation
- C. Section 23 0593 Testing, Balancing and Adjusting
- D. Section 23 0923 Building Automation and Temp Control System
- E. Section 23 0933 Electronic Automatic Controls
- F. Section 23 0943 Pneumatic Automatic Controls
- G. Section 23 3315 Fire, Smoke and Combination Fire/Smoke Dampers
- H. Section 23 3713 Grilles, Registers, and Diffusers

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide data on damper performance including, but not limited to, total static pressure drop verses airflow shown for all multi-blade dampers, size and quantity of dampers required.
- C. Provide shop drawing showing multi-blade damper dimensions, construction, duct connection sizes and electrical requirements.
- D. Provide manufacturer's instructions, indicate installation and support requirements.
- E. Provide an Indoor Air Quality Management Plan following the procedures set forth in the SMACNA "IAQ Guidelines for Occupied Building Under Construction".

1.4 STANDARDS

- A. Refer to the SMACNA "HVAC Duct Construction Standards, Metal and Flexible", latest edition.
- B. Refer to the SMACNA "Duct Cleanliness for New Construction Guidelines", latest printing.
- C. Unless noted otherwise herein, all ductwork shall be constructed, sealed, and supported in strict compliance with the SMACNA standards referenced above.
- D. UL 181A Closure Systems for Use with Rigid Air Ducts.
- E. UL 181B Closure Systems for Use with Flexible Air Ducts and Air Connectors.
- F. Refer to the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction", latest edition, for both new construction and renovation work.

1.5 PRESSURE AND VELOCITY RATINGS

- A. In supply air systems with terminals, ductwork shall be constructed and reinforced for 4000 FPM and 6" static pressure between fan outlet and terminal inlets, unless otherwise noted. This construction shall be referred to as "medium pressure".
- B. Ductwork downstream of terminals, return ductwork, and exhaust ductwork, unless otherwise noted, shall be constructed and reinforced for 2000 FPM velocity and 2" static positive or negative, unless otherwise noted. This construction shall be referred to as "low pressure".
- C. For all ductwork required to be constructed and reinforced for over 2" positive or negative pressure, submit a Ductwork Reinforcing Schedule. This schedule shall indicate size, metal gauge, and reinforcement size and spacing, for all ductwork over 2" pressure class.

1.6 DUCT DIMENSIONS

- A. Duct sizes shown on drawings provide the minimum cross-sectional area required. Increase overall duct dimensions as necessary to accommodate duct liner thickness.

PART 2: PRODUCTS

2.1 METAL MATERIALS

- A. Sheetmetal shall be hot dipped galvanized steel of lock forming quality with minimum zinc coating of 1.25 ounces per square foot each side per ASTM A525. Exposed duct to be painted shall be "paint-grip" type or treated to accept paint.
- B. Shower exhausts and kitchen dishwasher exhausts shall be constructed from aluminum flat sheet, type 3003-H14.
- C. Dryer vents shall be constructed of 20 gauge (minimum) stainless steel factory fabricated low-pressure spiral lock seam type. Elbows and fittings shall be die-stamped type of the same material with fully welded seams and no protrusions into the airstream.
- D. Lab hood exhaust ductwork shall be 316 stainless steel, all welded, including longitudinal joints, 16 gauge unless otherwise noted.
- E. Formed reinforcing drives, slips, pocket locks, and standing seams shall be constructed from sheet metal stock of the same material as the associated ductwork. Intermediate reinforcing angles may be uncoated steel painted with two coats of primer.
- F. Round and flat oval ductwork shall be factory fabricated low-pressure spiral lock seam type constructed in accordance with the above-referenced SMACNA standards. Round snap-lock type ductwork shall not be installed on project. All fittings shall be factory fabricated by same manufacturer as ductwork. Round duct below grade shall be minimum 20 gauge. Manufacturers shall be Semco, Monroe Metal, United Sheet Metal, or Lindab.

2.2 FIBERGLASS FLEXIBLE DUCT LINER

- A. Internal flexible glass fiber liner shall meet the requirements of ASTM C1071 Type I. Duct liner shall be 1" thick, minimum 1½ lb. density, with coated finished internal surface suitable for duct velocities to 6000 f.p.m., without erosion. Thermal conductivity shall not exceed 0.24 at 75°F. Liner surface coating shall have an EPA registered, anti-microbial agent to guard against potential growth of fungus and bacteria and have passed the testing of ASTM C1338. Duct liner shall provide a minimum NRC of 0.70 when tested in accordance with ASTM C518. Duct liner shall be by CertainTeed, Johns Manville, Knauf, or Owens Corning.

2.3 ELASTOMERIC FLEXIBLE DUCT LINER

- A. Internal flexible, closed-cell non-wicking elastomeric liner shall be pinned, fabricated factory-applied duct insulation with a self-adhering backing in sheet form. Liner shall meet the requirements of ASTM C534 for elastomeric insulation. Insulation shall be made with an EPA registered, anti-microbial agent to guard against potential growth of fungus and bacteria and shall meet UL181 for mold growth, and ASTM G21 and G22 for fungi and bacterial resistance. Duct liner shall be 1" thick, minimum 3 lb. density, with surface suitable for duct velocities to 6000 f.p.m. without erosion. Thermal conductivity shall not exceed 0.27 at 75°F and a maximum water vapor transmission of 0.08 perm-inches. Liner shall be manufactured without the use of CFCs, HFCs, or HCFCs and shall be formaldehyde free, low VOC, fiber free and dust free. Materials shall have a flame spread index of less than 25 and a smoke-developed index of less than 50 when tested in accordance with ASTM E84.

2.4 ROUND MEDIUM PRESSURE DUCTWORK

- A. Medium pressure round ductwork shall be manufactured or fabricated spiral lockseam conduit with duct and fittings constructed per referenced SMACNA standards.
- B. Joints shall be made with beaded slip coupling to 20" size and three (3) piece gasketed flanged joints for sizes 21" to 72". For 73" size and up, use companion angle flanged joints as defined in SMACNA standards.
- C. Branch fittings and reducers shall be metal spinnings, minimum 20 gauge.
- D. Elbows shall be mitered or stamped type with center line radius of 1½ times duct diameter. Mitered elbows shall be minimum all welded five-section type.
- E. 45° "Y" fittings shall be used at takeoffs from round duct.

2.5 PLENUMS AND CASINGS

- A. Field-fabricated plenums and casings shall be constructed per referenced SMACNA standards, except minimum steel gauge shall be 18 and minimum angle size 1" x 1" x 1/8". Angles shall be galvanized. Access doors shall be hinged, gasketed, and latched. Minimum size shall be 20" width by 48" high unless casing is 60" or less high. Door height shall be adjusted to 12" less than casing height for casings less than 60" high. All plenums shall be lined with 1" (2") thick rigid Type II duct liner.
- B. Cover entire surface of plenum over liner with 22 gauge perforated galvanized sheets with 1/8" diameter openings on 5/8" centers, attached with stick clips spaced at 18" on center each way, spot welded with 1" galvanized disc washers.
- C. Cover entire surface of plenum over liner with 1/2" x 1/2" galvanized hardware cloth secured with metal fasteners 18" on center both ways.

2.6 ACCESSORIES

- A. Low pressure splitter damper constructed of same material and two gauges heavier than ductwork in which installed. Damper heel shall be attached to cold-rolled galvanized steel pivot rod minimum ¼" diameter, with bearing at each end. Damper leading edge shall be adjusted by a cold-rolled galvanized steel control rod which passes through a lockable ball joint bracket installed on duct exterior.

- B. Low pressure single blade manual dampers shall be constructed in accordance with Figure 2.12 of referenced SMACNA standards, except as noted. Provide end bearings and continuous rods on all dampers except those 10" round and smaller in 1" pressure class ductwork. Single blade dampers shall not be used in ducts over 30" in one dimension.
- C. Access doors shall be galvanized steel hinged and latched insulated type, minimum 8" x 8" size, manufactured per referenced SMACNA standards. Where access to equipment requires a larger door, size shall be increased to allow full accessibility. Hinges shall be furnished with brass pins. Where hinges do not allow for access, latches shall be provided on all sides. Manufacturers shall be Air Balance, Krueger, Nailor, Ruskin, or Ventlok.
- D. Flexible ductwork in low-pressure systems shall be factory fabricated Class 1 type rated for a minimum of 4" positive or ¾" negative static pressure. In medium pressure systems, flexible ductwork shall be rated for 10" positive and 1" negative static pressure. All flex ductwork shall be insulated type, tested in accordance with UL 181, with a minimum R-value of 6.0. Construction shall be metalized polyester over galvanized steel wire or vinyl impregnated fiberglass on tedlar covered steel helix or spiral. Insulation shall be 1" thick fiberglass with vapor barrier jacket. Manufacturers shall be Atco, Flexmaster, or Thermaflex.
- E. Low pressure spin-in fittings with dampers shall be furnished at round duct run-outs to diffusers, grilles, and registers unless otherwise show on the drawings. Fittings shall be spin-in type (stick-on type is not acceptable) complete with damper, 3/8" square one-piece damper shaft, nylon shaft bushings at exterior duct wall penetrations, 2" stand-off bracket, locking quadrant, and factory sealed longitudinal seams. Barrel leakage to be less than 1 cfm at 4" sp. Fittings shall be constructed in accordance with referenced SMACNA standards. Fittings shall be Flexmaster FLD-B03 with sealed seams or equal by Crown or Jer-Air.
- F. Flexible duct connectors shall be non-combustible glass fabric of 30 oz. per square yard minimum weight fabric, coated on each side with fire-retardant Neoprene for indoor applications and Hypalon on exterior applications. Fabric shall be 3" wide and attached at each edge with a strip of 24-gauge galvanized steel. Material shall be tested in accordance with UL 181 and shall be suitable for contained exposure 200°F continuously.
- G. Low VOC water based duct sealing compounds shall be manufactured to comply with NFPA 90A, UL listed and complying with ASTM E84. The sealants must be rated for high pressure applications, both indoor and outdoor, and also comply with the current VOC limits of the Bay Area Air Quality Management District Regulation 8, Rule 51, with a maximum VOC emission of 250 grams per liter. Sealants shall be by Ductmate, Foster, or Hardcast. Pressure sensitive tape is not acceptable.
- H. Intake and relief hoods shall be aluminum construction of the low silhouette type complete with 1" fiberglass insulation, bird screen, hinged hood, reinforcing angles, mounting base and insulated twin-shell curb unit. Acme, Jenn-Air, Greenheck, or PennBarry.

2.7 MANUAL VOLUME DAMPERS

- A. Manual dampers shall be multi-blade opposed action type. Frames shall be formed 13-gauge galvanized steel channel with corner braces above size 20" wide and 20" high. Maximum individual damper width shall not exceed 48". Blades shall be 6" (maximum) wide, constructed of 16 U.S. Gauge (minimum thickness) formed galvanized steel attached to cold-rolled galvanized steel axles. Axle bearings shall be self-lubricating nylon or Teflon. Damper shall be controlled by factory assembled operating linkages concealed in the frame outside of airstream, constructed of galvanized steel. Provide adjustable locking quadrant at each damper section. Ruskin CD35 or equal by Arrow United, Cesco, Greenheck, or National Controlled Air.

2.8 CONTROL DAMPERS

- A. See Section 23 0923 Building Automation and Temperature Control System for control dampers.

2.9 BOILER BREECHING AND STACK

- A. Boiler breeching and vent shall be 10-gauge welded carbon steel with all welded mitered fittings and joints, insulated roof thimble and downdraft proof cap.

PART 3: EXECUTION

3.1 GENERAL DUCTWORK INSTALLATION

- A. All ductwork shall be fabricated, stored, and installed per the SMACNA "Duct Cleanliness Guidelines for Intermediate Level Cleanliness". This guide includes the requirement for ducts to be stored in a clean, dry area, the installation area shall be protected from the elements, and temporary closure of open ends on completed ducts, and other measures intended to minimize contamination of the circulating air.
- B. Develop and implement an Indoor Air Quality Management Plan that meets or exceeds the procedures set forth in the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction".
- C. Provide offsets, elbows, and transitions to coordinate with other work. Changes in shape or dimension shall be made with a maximum slope as noted in SMACNA HVAC Duct Construction Standards.
- D. Ducts over 12" in either dimension, except those to be externally insulated with rigid board or internally insulated, shall have all sides cross.
- E. Leave system clean from dust, trash, and foreign matter.
- F. Installation shall be air tight and free from rattles, vibration, and movement.
- G. Provide access doors for access to fire dampers, controls, coils, duct smoke detectors, humidifiers, and where required for cleaning, oiling, inspection, and maintenance.
- H. Paint interior ductwork visible behind grilles or register flat black.

3.2 DUCTWORK SUPPORT

- A. Ductwork shall be supported per SMACNA standards except hanger spacing shall not exceed 8' for rectangular duct and 10' for round rigid ductwork.
- B. Ductwork penetrating floors in equipment rooms shall be provided with a 4" high concrete curb around the duct.
- C. Support vertical risers at each floor.

3.3 LOW PRESSURE DUCTWORK

- A. Squared and radiused elbows shall be constructed as per Figure 2-2 of referenced SMACNA standards, except no mitered elbows or square elbows without vanes are allowed. Turning vanes shall be constructed as per Figures 2-3 and 2-4.
- B. Divided flow branches shall be constructed as per Figure 2-5 of referenced SMACNA standards, always with splitter damper.

- C. TDC and TDF duct joint systems may be used as outlined in SMACNA standards, provided corner pieces are used and bolted at all locations.

3.4 MEDIUM PRESSURE DUCTWORK

- A. Rectangular ductwork shall have only radiused elbows, with radius equal to 1½ times the duct width wherever possible. Where radius is less than 1½ times the duct width, turning vanes shall be installed as per Figures 2-3 and 2-4 of referenced SMACNA standards.
- B. Divided flow branches shall be constructed as per Figure 2-5 of referenced SMACNA standards, except no splitter dampers are to be installed.
- C. Round branch duct takeoffs from round or rectangular duct shall be as detailed on the plans. Straight taps or spin ins shall not be used in medium pressure duct.
- D. Splitter dampers shall not be used in medium pressure ductwork.
- E. Round and flat ductwork shall be assembled with sheet metal screws and duct sealer installed on slip joints.
- F. TDC and TDF duct joint systems may be used as outlined in SMACNA standards, provided corner joints are bolted at all locations.

3.5 DUCT SEALING

- A. Seal Levels:
 - 1. Seal level A – Seal all transverse joints, longitudinal seams, and all duct wall penetrations.
 - 2. Seal Level B – Seal all transverse joints and longitudinal seams.
 - 3. Seal Level C – Seal all transverse joints.
- B. Seal Procedures:
 - 1. All longitudinal and transverse joints, seams and connections in and between metallic and non-metallic ducts shall be constructed as specified in SMACNA HVAC Duct Construction Standards.
 - 2. Seal joints per SMACNA procedures with duct sealer as duct is erected. Sealing ductwork after erection is complete will not be accepted. Cover all joints to be sealed with sealer and assemble in normal fashion. Duct Seal Levels are as follows:
 - a. For Seal Level A and B: Pressure sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL 181A or UL 181B by and independent testing laboratory and the tape is used in accordance with that certification.
 - 3. Where ductwork is bolted together, provide 1/8" thick gaskets at each bolted joint.
 - 4. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, and other branch connections, access door frames and jambs, duct connections to equipment, etc.
 - 5. Closure systems used to seal factory-made rigid air ducts or air connectors shall comply with UL 181A and shall be marked "181A-P" for pressure-sensitive tape, "181A-M" for mastic, or "181A-H" for heat-sensitive tape.
 - 6. Closure systems used to seal flexible air ducts and flexible air connectors shall comply with UL 181B and shall be marked "181B-FX" for pressure-sensitive tape or "181B-M" for mastic.

7. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Mechanical fasteners for use with flexible nonmetallic air ducts shall comply UL 181B and shall be marked "181B-C".
 8. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage.
 9. Unlisted duct tape is not permitted as a sealant on any duct.
- C. All low pressure ductwork shall be sealed as follows:
1. Exterior – Seal Level A, except for exhaust ducts, which shall be Seal Level C.
 2. Unconditioned Interior Space – Seal Level B except for exhaust ducts, which shall be Seal Level C.
 3. Plenums or Conditioned Space – Seal Level C, except for exhaust ducts, which shall be Seal Level B.
- D. All medium pressure ductwork and all ductwork that will operate at over 2" static pressure shall be sealed as follows:
1. Exterior – Seal Level A, except for exhaust ducts, which shall be Seal Level C.
 2. Unconditioned Interior Space – Seal Level A except for return ducts, which shall be Seal Level B, and exhaust ducts, which shall be Seal Level C.
 3. Plenums or Conditioned Space – Seal Level B, except for return ducts, which shall be Seal Level C.

3.6 FLEXIBLE DUCTWORK INSTALLATION

- A. Flexible duct shall be sealed and mechanically fastened to both the supply end and the air distribution (diffuser) end. See Duct Sealing section above for information on sealing and closure systems.
- B. Flex duct shall be installed full size of diffuser unless otherwise shown. Maximum length of flexible duct shall not exceed 7' at diffusers and 2' at terminal inlets.
- C. Where length of diffusers runout exceeds 7', use low-pressure duct for extension. Secure flexible ductwork at all connections to diffusers, terminals, and round ductwork with UL listed ductstrap. Secure strap over flexible duct liner and cover with duct insulation and vapor barrier jacket.
- D. Flexible ductwork to be supported per SMACNA Standards.
- E. Flex ductwork shall not be used in exhaust or return duct systems.

3.7 DUCTS THROUGH FIRE RATED WALLS AND FLOORS

- A. Ducts through fire rated walls and floors shall have areas around exterior of duct or insulation sealed with fire barrier material. See Section 23 0500 Common Work Results HVAC.
- B. Provide one 20" x 20" access panel for personnel entry. Access panels shall be provided every 12' with bottom 1½" above bottom of ductwork, constructed of same material as the ductwork. Access doors shall be gasketed or sealed with 1500°F rated material, bolted to the ductwork with carbon steel studs welded to the surface of the duct. Access panels shall be grease tight.
- C. See Section 23 0700 HVAC Insulation for range hood exhaust duct insulation.
- D. Maintain duct clearances to combustibles as per NFPA 96.

- E. Perform light testing of all welded joints per paragraph 506.3.3.31 of the International Mechanical Code.

3.8 DUCTWORK LEAKAGE TESTING

- A. Provide necessary coordination with the Testing agency to schedule leakage testing. Provide temporary blank-off panels or plugs as required to perform the leakage testing. Temporary panels and plugs shall be removed after leakage testing is completed.
- B. Correct any leaking joints or assemblies as required to comply with the leakage testing requirements.
- C. Ductwork shall not be covered with insulation until compliance with the leakage test requirements have been met.

END OF SECTION 23 3100

**SECTION 23 3713
GRILLES, REGISTERS, AND DIFFUSERS**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies grilles, registers, and diffusers furnished and installed under Division 23.

1.2 RELATED SECTION

- A. Section 23 3100 Ductwork

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide data on air distribution performance including, but not limited to, total static pressure drop and sound generation (NC) verses airflow shown for each supply and return grille, size, and quantity of grilles required.
- C. Provide shop drawing showing catalog illustrations, dimensions, duct connection sizes, and accessories.
- D. Provide manufacturer's instructions; indicate installation and support requirements.

1.4 QUALITY ASSURANCE

- A. Performance of grilles, registers, and diffusers shall be tested in accordance with ANSI/ASHRAE Standard 70, latest edition.
- B. All grilles, registers, and diffusers shall be selected and furnished by one manufacturer.

PART 2: PRODUCTS

2.1 GENERAL

- A. Grilles, registers, and diffusers have been selected from one manufacturer's catalog. Alternate manufacturers shall be Titus, Metalaire, E. H. Price, Krueger, Carnes, Anemostat, Tuttle & Bailey, or Nailor Industries.
- B. All grilles and registers with borders shall be furnished with gasketed seals around the perimeter. All grilles, registers, and diffusers shall be aluminum or steel, as scheduled.
- C. Register dampers shall be gang operated opposed blade type, operable through the face of the diffuser.
- D. Extractors shall be gang operated with galvanized steel construction, 2" blade spacing, fully adjustable blades, with thru key operated screw at different face, Titus AG-225 with operator #3.
- E. Door grilles shall be sight proof, aluminum offset blade type with adjustable frame, Titus CT-700.

PART 3: EXECUTION**3.1 TEMPORARY DUST PROTECTION**

- A. To prevent the circulation of construction dust in the building, protect all air outlets on the new and existing zones being modified with two layers of Grade 80 cheesecloth sprayed with a saturating coat of approved odorless oil, having a flashpoint of not less than 350°F.
- B. Apply dust protection to each register, grille or diffuser before any duct construction work is started. Maintain dust protection as directed by Owner.

3.2 INSTALLATION

- A. Attach ceiling diffusers to flex duct connection in a secure fashion with sheet metal straps screwed in place or tightly secured UL listed draw bands.
- B. Install offset return grilles so that blade offset is angled down towards the floor.
- C. Coordinate exact location of ceiling diffusers and grilles with reflected ceiling plan.

END OF SECTION 23 3713

**SECTION 23 631
ELECTRIC HOT WATER HEATING BOILER**

PART 1 : GENERAL

1.1 DESCRIPTION: This section specifies the requirements for the electric-type hot water heating boilers.

1.1 QUALITY ASSURANCE:

- A. Boilers shall be ASME constructed and stamped for 150 psig working pressure and registered with the National Board of Boiler and Pressure Vessel Inspectors.
- B. Boilers shall be U.L. listed and approved.
- C. The boilers shall be provided with a one (1) year parts warranty. Warranty shall be for a period of 12 months from the date of factory start-up or 18 months from date of delivery, whichever occurs first.

1.1 SUBMITTALS:

- A. A wiring diagram showing all power and control wiring shall be furnished by the manufacturer for use in incorporation into the project control diagrams. Control voltage wiring and line voltage wiring shall be separately designated on the boiler wiring diagram.
- B. A minimum of three (3) sets of Operating and Maintenance manuals shall be provided.

PART 2 - PRODUCTS

2.1 BOILER:

- A. Boiler shall be of the vertical-type and fabricated from carbon steel with a minimum thickness of 0.25 inches. Boiler shall have a minimum capacity of 75 gallons. There shall be a minimum clearance of four inches (4") between the heating elements and the bottom of the pressure vessel. The boiler shall be insulated with a fiberglass blanket of minimum 3½" thickness and 3 lb./cu. ft. density. Boiler vessel shall be mounted on a heavy-duty steel channel mounting frame with lifting lugs provided. An 18 gauge thickness metal enclosure shall be provided around the boiler vessel.
- B. The mounting frame and the metal enclosure shall be electro-galvanized and phosphate coat bonderized for protection against corrosion and to provide maximum paint adhesion. Mounting frame and the metal enclosure shall be painted with high-heat resistant silicon-acrylic enamel. The control panel shall be painted with epoxy paint.
- C. immersion heaters shall be incoloy-sheathed, resistance-type with single U-bend tubular heating blades and provided with element spacers along the length of the elements. Elements shall be epoxy sealed and individually removable. Elements shall be rated for a maximum of 75 watts per square inch with a maximum of 20 kW capacity each. Heating elements shall be flange mounted with bolted steel flanges with a flange-to-flange connection with the boiler vessel. Heating element mounting flanges shall not be directly threaded into the shell of the pressure vessel. Heating stages shall be configured for equal wattage and have balanced circuits on the electrical supply phases and with each load branch circuit limited to a maximum of 48 Amps. Provide a minimum of ten (10) stages of heating capacity per each boiler.

ELECTRIC HOT WATER HEATING BOILER

- D. Water controls shall include ASME rated pressure relief valve; a primary, automatic-reset type high temperature limit cutout; a secondary, manual-reset high temperature limit cutout; a primary, automatic-reset probe-type or float-type low water cutoff; a secondary, manual-reset probe-type low water cutoff; and a flow switch. Provide factory installed controls capability as follows for interfacing with the building automation system: remote start/stop, remote enable/disable of each stage of heating capacity and a remote reset of the supply water leaving temperature setpoint via a remote input 4-to-20 mA DC signal.
- E. Boiler shall be provided with the following accessory items: pressure and temperature gauges, drain down line, pressure relief valve, an air purge outlet, and inspection opening.
- F. Electrical conductors shall be aluminum or copper and shall be arranged for top-inlet electrical power connection.
- G. All electrical components and controls shall be pre-wired and factory tested and shall include:
 - 1. Control panel shall be a unit-mounted, ventilated, NEMA-1 enclosure with a ventilated air gap provided between the panel and the boiler.
 - 2. Non-fused disconnect switch face with a shunt-trip mechanism mounted on the panel door and interlocked with the panel door to prevent access into the control panel without disconnect of the power.
 - 3. Separate terminal blocks for control and power wiring.
 - 4. Magnetic contactors with silver alloy contacts and U.L. listed for 100,000 cycles. Contactors shall break all ungrounded conductors and shall be assembled and factory pre-wired to heating elements and source connector terminals.
 - 5. Fuses with each heating element or circuit.
 - 6. A solid state-type load sequencer with "first-on/first-off" sequencing, time delay between cycling ON/OFF of each heating step, and recycling relay to return the controller to the OFF position after power failure.
 - 7. Dry-type controls transformer with fused primary and 120 volt fused secondary and a control circuit switch.
 - 8. Control panel with amp interrupt rating of 60,000 amps.
 - 9. ON-OFF switch for the boiler with an "ON" indicating lamp.
 - 10. Pilot lights with identification label for each heating step.
- H. Boiler shall be Precision model PCW, Fulton, Sussman model SVW, or Cleaver-Brooks model CWB.

PART 3 - EXECUTION**3.1 BOILER START-UP:**

- A. The contractor shall receive, set, install, pipe-up, start-up and check-out the boiler and related accessories for proper operation including, but not be limited to: all related automatic control system components and sequences-of-control, drain line and drain line valve, relief valve and extension of the relief valve discharge to an adjacent floor drain.
- B. Provide the services of a factory trained technician to place the boiler in operation and instruct the Owner's representative in operation and maintenance of the system. An operational test of the boiler performance shall be made at this time and the report submitted in triplicate to the Engineer.
- C. Provide four (4) hours of instruction time for the Owner's representative in operation and maintenance of the system. This instruction time shall be separate from and in addition to the boiler start-up time noted in paragraph 3.01.A.

3.1 BOILER INSPECTION:

- A. Boiler shall be checked and piping inspected by the Georgia Department of Labor, Boiler Inspections (phone number 404-656-2966) prior to start-up. The contractor shall arrange for this inspection and pay all related permits and fees. Contractor shall obtain boiler permit prior to final inspection.
- B. Submit inspection report to the Engineer in triplicate.

3.1 REGISTRATION DOCUMENTS: The boiler manufacturer shall provide the certificate of ASME construction and provide the National Board of Boiler and Pressure Vessel Inspectors registration documentation.

END OF SECTION

**SECTION 23 5721
PLATE HEAT EXCHANGER**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements for plate heat exchangers.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 0100 Operation and Maintenance of HVAC Systems
- C. Section 23 0500 Common Work Results for HVAC
- D. Section 23 2113 Hydronic Piping System

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide data on unit performance including, but not limited to, entering water temperatures, leaving water temperatures, capacity, and chilled water and condenser water flow and associated pressure drop.
- C. Provide shop drawing showing heat exchanger dimensions, weight, materials of construction, pressure rating, and service access requirements. Shop drawings shall indicate connection sizes and locations for inlet and outlet of hot and cold fluids. Heat exchanger shall be shipped with these same connections physically identified.
- D. Provide manufacturer's instructions; indicate installation and support requirements.
- E. Provide operation and maintenance procedures; include start-up instructions, assembly drawings, and parts list.

1.4 QUALITY ASSURANCE

- A. Heat exchanger capacity shall be rated in accordance with AHRI 400.

PART 2: PRODUCTS

2.1 PLATE HEAT EXCHANGER

- A. Heat exchanger shall be plate and frame type factory-assembled and tested.
- B. Construction shall be of 304 stainless steel plates, minimum thickness of 0.5mm, formed into herringbone patterns mounted between a fixed and movable carbon steel head plate with grille rods and tie bolts. Molded one-piece mechanically rated EPDM or nitrile rubber gaskets shall be installed between stainless steel plate sections. Piping connections shall be ANSI flanged for 150 psi flange connections.
- C. Frame assembly shall be bolted carbon steel construction with no requirement for field welded reinforcement of stiffeners. Frame assembly shall be provided with epoxy-coated finish or two coats of polyurethane paint finish. Aluminum or stainless steel shroud shall cover entire assembly.

- D. Maximum frame height shall be 7'-0". Heat exchanger shall have a maximum of four (4) piping connections.
- E. Complete assembly shall be assembled and tested in accordance with ASME Code, Section VIII, Division I, and stamped for a design pressure of 150 psig for both hot and cold sides. Test pressure shall be at least 150% of design pressure listed.
- F. Frame shall be sized for the capacity to accommodate 20% future additional plates.
- G. Heat exchanger shall be by Bell and Gossett, Mueller, Graham, Alfa-Laval, or Sondex.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Install heat exchanger in accordance with manufacturer's instructions and drawing details.
- B. Unit shall be hydrostatically tested for working pressure in accordance with the ASME Code. Any leaks shall be repaired, and the unit retested with a letter from manufacturer's representative witnessing the test.

END OF SECTION 23 5721

**SECTION 23 6500
COOLING TOWER**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements for the cooling tower.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
- B. Section 23 0100 Operation and Maintenance of HVAC Systems
- C. Section 23 0500 Common Work Results for HVAC
- D. Section 23 2113 Hydronic Piping
- E. Section 23 0514 Variable Frequency Drives

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide data on unit performance including, but not limited to, entering water/air temperature, leaving water temperature, capacity, condenser water flow, fan motor and basin heater electrical requirements and accessories.
- C. Provide shop drawing showing tower dimensions, weight, materials of construction, service access requirements, and pipe connection sizes and locations.
- D. Provide manufacturer's instructions; indicate installation and support requirements.
- E. Provide operation and maintenance procedures; include start-up instructions, assembly drawings, and parts list.

1.4 QUALITY ASSURANCE

- A. Materials used shall meet the requirements of NFPA 220 for non-combustible construction.
- B. Performance shall be certified by the Cooling Tower Institute in accordance with CTI Standard STD-201, or field performance tested in accordance with CTI acceptance test code ATC-105.
- C. Wet deck surface and eliminators shall be Factory Mutual approved.

PART 2: PRODUCTS

2.1 COUNTERFLOW INDUCED DRAFT TOWER

- A. Cooling tower shall be single cell, induced draft, counterflow type, factory assembled, with top discharge. Towers shall be Evapco.
- B. Structural framework shall be steel designed for operating loads and a 30 psf wind pressure on any projected area. All steel shall be galvanized with a zinc coating not less than 2½ oz. per square foot.

- C. Casing panels shall be constructed from G-235 hot-dip galvanized steel.
- D. The hot water distribution system shall be rigid piping with threaded ABS spray nozzles with integral sludge ring. Spray headers and branches shall be constructed of schedule 40 polyvinyl chloride (PVC) with steel connection for attachment to external piping. Each distribution basin shall be furnished with a flow control valve.
- E. Air inlet louver screen shall be polyvinyl chloride (PVC) designed to minimize air resistance and prevent water splash out. Fill and drift eliminator material shall be non-corrosive and non-ferrous. Fill and eliminators shall consist of formed polyvinyl chloride plastic with a flame spread rate of 5 or less. Drift loss shall not exceed 0.005% of the circulating rate.
- F. Fans shall be propeller type with multiple cast aluminum alloy blades driven by a V-belt drive. Bearings shall be self-aligning, heavy duty, grease packed with moisture proof seals and integral slinger rings. All bearings shall be designed for a minimum L10 life of 40,000 hours. Motor shall be totally enclosed inverter duty type specifically designed for cooling tower application, including special moisture protection on the windings, bearings, and shaft. A tapered steel fan cylinder shall be provided to minimize tip loss.
- G. A 7-gauge steel removable fan guard shall be provided over the fan cylinder.
- H. Cold water basin shall be bolted stainless steel. Basins shall be self-cleaning complete with 10-gauge depressed center section, basket strainer, side suction (coordinate location with drawings), cleanout, overflow, and drain fittings.
- I. Make-up shall be via bronze float operated valve, furnished with the tower and adjusted to maintain recommended basin water level.
- J. Make-up shall be via electric conductance type level controller with solenoid valve furnished with the tower. Controller shall provide open and close signal to the valve to maintain proper water level and include a low basin water alarm contact.
- K. Make-up shall be via electronic continuous level sensor with solenoid valve furnished with the tower. Sensor shall use RF admittance technology with NEMA 4 enclosure, a 316 stainless steel probe, and provide a 4-20 mA output to the building automation system that will open and close the valve to maintain proper water level. Provide Dwyer Model CRF or equal. Sensor length shall be coordinated with basins/tank depth prior to ordering. Provide separate ground rod for non-metallic basin/tank applications.
- L. A man-sized access door and OSHA compliant ladder shall be provided for access to the fan drive, eliminator, and plenum area. Provide external service platform as required to service the fan drive.
- M. Capacity shall be as scheduled on drawings.
- N. Propeller fan-type cooling towers shall meet or exceed ASHRAE 90.1 (current edition) Performance Requirements:

All capacities, Performance Requirement ≥ 38.2 GPM/Hp
- O. Basin Heaters shall be UL listed immersion type with capacity as scheduled.
 - 1. Provide mechanical safety float switch, water temperature switch, and NEMA 3 rated contactor with circuit breaker.
 - 2. Heater assembly shall be factory installed.
- P. Provide a 5-year labor and material warranty against leakage on the cold water basin.

- Q. Provide a 5-year labor and material warranty on the tower fan drive train system.
- R. Provide OSHA compliant railing and ladder for access to the hot deck, including full perimeter handrail.
- S. Provide a vibration cutout switch to stop the fan motor when activated due to loss of fan balance.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Prior to installing tower, verify that supporting steel grillage is proper for tower that is provided. Tower is to be mounted level. Mount top of towers at top of the screen.
- B. Only the pipe on top of tower may be supported by tower structure. All other pipe must be supported by supporting steel grillage or building structure.
- C. Bolt tower base or isolators to structural steel frame.

3.2 FREEZE PROTECTION

- A. Install electric heat tape on all supply, return, makeup, drain and bypass lines prior to insulating pipe.

3.3 BALANCING

- A. Adjust tower distribution valves to give uniform flow rates across all sections.

END OF SECTION 23 6500

**SECTION 23 8146
WATER-COOLED HEAT PUMP**

PART 1: GENERAL

1.1 DESCRIPTION

- A. This section specifies the requirements for water source heat pumps, 5 tons and smaller.

1.2 RELATED SECTIONS

- A. Section 23 0010 General Provisions HVAC
B. Section 23 0100 Operation and Maintenance of HVAC Systems

1.3 SUBMITTALS

- A. See General Conditions for submittal procedure.
- B. Provide data on unit performance including, but not limited to, entering air/water temperatures, leaving air/water temperatures, airflow and total static pressure, water flow and pressure drop, supply fan motor horsepower, total and sensible capacity, applicable AHRI SEER, EER, and COP values.
- C. Provide shop drawing showing unit dimensions, weight, electrical requirements, service access requirements, duct connection sizes and locations, and pipe connection sizes and locations.
- D. Provide manufacturer's instructions; indicate installation and support requirements.
- E. Provide operation and maintenance procedures; include start-up instructions, assembly drawings, and parts list.

1.4 QUALITY ASSURANCE

- A. Heat pump performance shall be rated in accordance with AHRI Standard 320 and ISO 13256-1.
- B. Heat pumps shall be UL listed.

1.5 EXTENDED WARRANTY

- A. Compressors for each unit shall be provided with an extended four-year warranty after completion of the one-year warranty.

PART 2: PRODUCTS

2.1 WATER-COOLED HEAT PUMPS

- A. Heat pumps shall be either horizontal or vertical (as noted on drawings) water-cooled type complete with condenser, evaporator coil, fan, refrigerant piping, compressor, reversing valve, filter, and controls factory assembled.

- B. Unit housing shall be galvanized steel. The cabinet shall be compartmentalized with the compressor, reversing valve and water coil out of the air stream. All interior surfaces shall be lined with fiberglass insulation. Service access shall be through insulated access panels on the sides of the unit which shall provide access to all components. The unit shall have hanger brackets which prevent the hanger rod from extending below the unit frame.
- C. Compressor controls shall include high-pressure cutout and thermal overload protection.
- D. Evaporator fans shall be direct drive, forward curved, operating at 1200 rpm or less with thermal overload protection. Motors shall be minimum 3-speed multi-tap type with plug in speed change. Each heat pump shall have a fan relay. The blower housing shall have an orifice ring to allow removal of the motor and blower wheel together from one side of the unit.
- E. Units shall be furnished with mounting brackets. Provide minimum 36" long braided reinforced 200 psig rated flexible circulating water hoses with threaded metal ends and flare connection, 3/4" diameter for 2 tons and smaller and 1" diameter for 2.5 tons and larger. Provide a coupling to connect supply and return hoses to bypass unit during initial cleaning of piping systems. Rubber on hoses shall be approved for plenum installation.
- F. Condensate drain pan shall be stamped from a single sheet of galvanized steel and shall be insulated. Unit shall have a condensate overflow switch to electrically shut unit down.
- G. Air coil shall be copper tube with corrugated aluminum fins.
- H. Water refrigerant heat exchanger shall be a tube-in-tube type with working pressure of 450 psig. The outer wall shall be steel or copper and the inner wall shall be copper.
- I. Internal refrigerant piping shall be seamless copper tubing with all connections brazed.
- J. Reversing valve shall be a hermetic type with solenoid coil.
- K. Compressor shall be 3500 rpm hermetic type with internal and external vibration isolator mounting and built-in motor overload protection. The compressor shall be bolted to the unit frame.
- L. Filters shall be 1" thick UL listed disposable fiberglass type with scrim reinforced media and a minimum MERV 1 Rating (ASHRAE 52.2) with not more than a 0.2" initial pressure loss at 500 fpm face velocity. Filters shall be Airguard F312, American Air Filter Stratadensity, or equal.
- M. Each unit shall be provided with limit controls to prevent operation when an unsafe condition exists. A refrigerant high-pressure cutout shall de-energize the compressor if refrigerant pressure exceeds 395 psig. A low temperature thermostat with the sensing element directly in contact with the water shall de-energize the compressor if the condenser water leaving the unit falls below 40°F.
- N. Provide factory-mounted and wired motorized water flow control valve with rapid opening upon compressor start and slow closing upon compressor stop with controls as necessary to open valve upon compressor run.
- O. Heat pump manufacturer shall furnish standard 24-volt control board (terminal strip) for interface with the DDC system. Selected controls vendor will provide DDC unitary controllers to be field-mounted.
- P. Water-cooled unitary heat pumps shall meet or exceed ASHRAE 90.1 (current edition) Performance Requirements:

<17,000 BTUH, Min Efficiency* = 11.2 EER cooling and 4.2 COP heating
≥17,000 BTUH but < 65,000 BTUH, Min Efficiency* = 12.0 EER cooling and 4.2 COP heating
≥65,000 BTUH but < 135,000 BTUH, Min Efficiency* = 12.0 EER cooling and 4.2 COP heating

*Based on 86°F entering water during cooling and 68°F entering water during heating.

- Q. Water source heat pump units shall be by Trane, ClimateMaster, or Carrier.

PART 3: EXECUTION

3.1 INSTALLATION

- A. Support heat pumps as detailed with threaded rods for any horizontal configuration to be located above ceiling.
- B. Locate heat pumps to allow full access for service and removal.
- C. Units shall be installed above the ceiling in such a way that the amount of ceiling that must be removed for access shall be kept to an absolute minimum.
1. Maintain a minimum of 24" clearance in front of access panels to service controls, compressors, and blower motors.
 2. Maintain 18" clearance on other sides. Particular attention shall be given to location of condenser water mains and condensate drains in corridors.
- D. The Contractor shall completely install two units including electrical connection and the installation shall be inspected and approved by the Engineer, Architect, and the Construction Coordinator before proceeding with the installation of the remaining units.
- E. Change filters prior to final inspection. Every effort shall be made to keep filters clean during construction phase.
- F. of the work. Obtain receipt for these units.

END OF SECTION 23 8146

**SECTION 26 0000
ELECTRICAL GENERAL PROVISIONS**

PART 1 - GENERAL

1.1 SCOPE

- A. This section applies to all Sections of DIVISION 26 – ELECTRICAL.
- B. The general provisions of the contract, including General and Supplementary Conditions and General Requirements, apply to the work specified in this section and in all sections of this division.
- C. The project scope of work includes disconnection and reconnection, along with start-up of an existing generator set. The contractor shall hire a third-party NETA certified testing agency to perform ANSI/NETA ECS in conjunction with ANSI/NETA MTS for start-up testing of the existing generator.

1.2 WORK INCLUDED

- A. Provide all labor, tools, and materials required for a complete and fully operational installation, as described on the drawings or in the specification.
- B. The work shall be installed in a neat and workmanlike manner.

1.3 WORK NOT INCLUDED UNDER DIVISION 26

- A. The following items of work are specified under other divisions of the specification:
 - 1. Temporary service for construction.
 - 2. Electric motors.
 - 3. Electric heaters unless otherwise noted on the drawings.
 - 4. Control and interlock wiring for work furnished under other divisions, except where specifically required under this division.
 - 5. Access panels in walls or ceilings.
 - 6. Field finish painting, except for field painting of electrical material with paint supplied by the manufacturer of the material.
 - 7. Starters for certain items of equipment are furnished under other divisions for installation under this division.
- B. Refer to other sections of this division for work required in connection with the above items.

1.4 DEFINITIONS

- A. "Provide": furnish and install, complete and ready for operation.
- B. "Install": receive, mount, and connect, complete and ready for operation.

- C. "Wiring": wires and cables installed with all required raceways, connectors, and fittings.
- D. "Concealed": not exposed to view; embedded in masonry or other construction; in furred spaces or above suspended ceilings; below grade.
- E. "Exposed": not concealed; not embedded or installed underground; under raised floors; inside trenches, tunnels, and basements, inside built-up HVAC equipment, crawl spaces, and accessible attics.
- F. "The Drawings": that portion of the contract drawings annotated as electrical.
- G. "Furnish": Supply, deliver to job site, protect and store.
- H. "Engineer": Electrical Professional Engineer responsible for the Electrical portion of the Contract Documents.

1.5 ABBREVIATIONS

- A. The abbreviations used on the drawings and in the specification are defined as follows:
 - 1. "AC": Alternating Current
 - 2. "AFF": Height above Finished Floor
 - 3. "AIC": Ampere Interrupting Capacity
 - 4. "AICR": Ampere Interrupting Current Rating
 - 5. "AHJ": Authority Having Jurisdiction
 - 6. "NEC": National Electrical Code
 - 7. "NIC": Not in the Contract
 - 8. "NF": or "N/F": Non-fused
 - 9. "30A/2P": Example of a circuit designation for a 30 Amp 2-Pole fused switch or a 30 Amp 2-Pole circuit breaker or device.
 - 10. "FBO": Furnished by Others
 - 11. "EC": Electrical Contractor
 - 12. "EX": Existing to Remain
 - 13. "EXR": Existing Relocated – new location indicated on the drawings.
 - 14. "HP": Horsepower
 - 15. "kVA": Kilovolt Ampere
 - 16. "kW": Kilowatt
 - 17. "MCC": Motor Control Center
 - 18. "MLO": Main Lugs Only
 - 19. "NTS": Not to Scale
 - 20. "WP": Weatherproof
 - 21. "U.L.": Underwriter's Laboratory

1.6 CODES, RULES, AND REGULATIONS

- A. Comply with the following:
 - 1. NFPA 70 National Electrical Code – 2014.
 - 2. All applicable laws and ordinances.
 - 3. The rules and regulations of electric utility company serving the project applicable to the installation of service and metering equipment.

4. The rules and regulations of the telephone company serving the project applicable to the work required for routing telephone service into the facility.
- B. Give all necessary notices, obtain all required permits, and pay all inspection and other fees imposed by Authorities Having Jurisdiction over the work.

1.7 STANDARDS

- A. The standards of the following organizations shall be applicable to the work:
1. The National Fire Protection Association (NFPA)
 2. Underwriters Laboratories (U.L.)
 3. National Electrical Manufacturers Association (NEMA)
 4. American National Standards Institute (ANSI)
 5. Institute of Electrical and Electronic Engineers (IEEE)
 6. Insulated Power Cable Engineers Association (IPECA)
 7. Illuminating Engineering Society of North America (IESNA)
 8. National Electrical Testing Association (NETA)
 9. National Electrical Contractors Association (NECA), Standard of Installation
 10. American Society for Testing and Materials (ASTM)
- B. Comply with the latest editions and Georgia Amendments of standards applicable to the work.

1.8 MATERIALS

- A. All material shall be new, and shall comply with the indicated standards.
- B. All material shall be UL labeled or UL listed, except where the material is of a type not included in the UL listing service, in which case the material shall comply with other applicable industry standards and the contractor shall provide any examinations or certifications required by the local inspection authority in lieu of UL listing.
- C. All material shall be of a suitable type and rating for the intended use, and shall be installed in conformance with the instructions and recommendations of the manufacturer.

1.9 DRAWINGS

- A. The drawings are schematic in nature and do not indicate all of the required details of the work. All materials customarily considered to be a part of the electrical work and normally required for a complete and operational installation, shall be provided without additional cost to the Owner.
- B. Refer also to the drawings of all other trades to coordinate the electrical installation.
- C. Equipment of other trades is shown schematically on the electrical drawings. Examine the drawings of the trade providing the equipment before roughing in the connections for it. Connect the equipment where actually installed, including wiring through any line voltage controllers, without any additional cost to the Owner.

- D. Prior to roughing in circuits for equipment furnished by other trades, and prior to releasing for manufacture panelboards, starters or motor control centers feeding such equipment coordinate the electrical provisions being planned with the trade providing the equipment and submit any conflicts in writing.
- E. The Engineer directs the location of any electrical outlet, or wall switch, or luminaries, or other equipment, to a location within 10 feet of the location shown on the drawings at no additional cost to the Owner provided such relocation is made prior to the installation of the equipment being relocated.

1.10 SUBMITTALS

- A. Submit shop drawings in the manner and form described elsewhere in the contract requirements.
- B. Submittals are required for material as noted in other sections of this division.
- C. Check shop drawings prior to submission and provide date and signature of checker on each item. Note all corrections. Note any requested deviation from the drawings or specification, or if none, then so indicate. The Engineer shall return documents without review where submitted without prior review by the contractor.
- D. Review of submittals will be only for general conformance with the design concept indicated on the drawings and in the specification and general compliance with the information given in the Contract Documents. Review will be made only of information clearly and specifically indicated in the submittal, and does not imply the acceptability of details, which are not so described in the submittal. Approval of a specific item shall not include approval of an assembly of which the item is a component. Contractor is responsible for: dimensions to be confirmed and correlated at the jobsite; information that pertains solely to the fabrication processes or to the means, methods, techniques, sequences and procedures of construction; coordination of the Work of all trades; and performing all work in a satisfactory manner.
- E. Review of the submittal documents by the Engineer does not relieve the contractor of the responsibility to comply with all requirements of the Contract Documents.

1.11 PROJECT CLOSEOUT

- A. Furnish closeout documents in the manner and form described elsewhere in the Contract Documents.
- B. Closeout documents shall include the following:
 - 1. Final shop drawings.
 - 2. As-built drawings including as-built field layout drawings.
 - 3. Operation and maintenance manuals.
 - 4. Receipts from the Owner stating that he has received satisfactory operational demonstrations and instruction for electrical systems.
 - 5. Signed receipts from the Owner for spare parts and materials that are specified to be furnished.
 - 6. Written guarantee.

7. All required certifications, including certificate of inspection approval of the code-enforcing authority.
8. All required test reports (include in operations and maintenance manual).

1.12 RECORD DRAWINGS AND SPECIFICATIONS

- A. Provide record drawings and specifications in the manner and form described elsewhere in the Contract Documents.
- B. Record drawings shall be maintained at the jobsite, and shall be available for review during construction.
- C. Record the final arrangement of the work and exact locations of the work as installed. Provide photographs of buried grounding work prior to backfill of trenches.
- D. Record drawings and specifications shall be kept current during the course of construction of the work.

1.13 OPERATION AND MAINTENCE MANUALS

- A. Provide minimum of (3) copy sets and (1) electronic set of all operation and maintenance manuals in the manner and form described elsewhere in the contract requirements.
 1. Electronic set shall clearly note the job name an Owner's name, work order number (WO #) and Bid Number on the label.
- B. Operation and Maintenance Manuals shall consist of the following as a minimum:
 1. Hardback three ring binders with job name and Owner's name, work order number (WO #) and Bid Number on the cover.
 2. Typed index listing name, address, and phone number of the General Contractor, Electrical Subcontractor, and Fire Alarm Subcontractor, and all major equipment suppliers.
 3. Typed table of contents, listing each Section, title, and number.
 4. All Sections shall be tabbed with plastic tabs listing Section numbers.
 5. Each item of equipment requiring maintenance and operation data as noted in each specification section shall be provided with an index listing the types of equipment installed. Submittal data shall be included to the extent necessary to identify equipment, including summary sheet. Instructions shall include type and suggested frequency of maintenance, oiling, cleaning, disassembly, and reassembly directions, and wiring diagrams.
 6. Make, model, serial number and purchase order number of every item of equipment shall be identified on all documentation.
 7. Letters, where factory startup or checking has been required, certifying completion of performance.
 8. Contractor's signed warranty letter certifying all work has been completed as required and stating what date warranty shall end.
 9. Parts list.
 10. Descriptive literature.
 11. Location, telephone number and contact information of contractors, distributors, dealers and authorized service agents.

12. Test reports and certifications.
 13. Record copies of all shop or submittal drawings and data.
 14. Copies of all software on diskette or compact disk, licensed to the Owner.
- C. Maintenance instructions and parts lists shall include the most detailed and advanced publications available from the equipment manufacturer.
 - D. Demonstrate the operation of the equipment to the Owner, including instruction in its use and operation. Provide instruction by manufacturers representatives where specified.
 - E. Provide operation and maintenance manuals for equipment and systems as specified by the sections in Division 26 & 28.

1.14 SPARE PARTS

- A. Furnish spare parts as specified by the sections in Division 26.
- B. Turn over spare parts to Owners representative. Store on site as directed by the Owner. Obtain written receipt detailing specific spare parts turned over and submit with close-out documents.
- C. Replace at no cost to the Owner any spare parts used from the Owners stock prior to substantial completion or for warranty related repairs.

1.15 GENERAL TESTING

- A. Test all parts of the work to verify compliance with the drawings and specification.
- B. Verify tightness of all mechanical and electrical connections.
- C. Verify integrity of all wiring systems to assure continuity, absence of unintentional grounds, and integrity of required grounds.
- D. Perform any required special factory or field testing as specified in the other sections of this division. Provide all wiring, instruments, and personnel required to complete these tests.
- E. Where other requirements of this division require testing in the presence of the Engineer, provide at least seven (7) business days advance written notice of such testing to the Engineer.
- F. Where other requirements of this division require submission of written records of tests and test results, accumulate and submit all such reports and include as a separate section in the operations and maintenance manuals described elsewhere in this section.

END OF SECTION

**SECTION 26 0500
BASIC MATERIALS AND METHODS**

PART 1 - GENERAL

1.1 GENERAL

- A. This section covers items of work required by more than one section of DIVISION 26 – ELECTRICAL.
- B. Refer to other Divisions for requirements pertaining to:
 - 1. Cutting and repairing
 - 2. Excavation and backfilling
 - 3. Concrete
 - 4. Field painting
 - 5. Equipment furnished under other Divisions and installed under this Division

1.2 SUBMITTAL DOCUMENTS

- A. Required for fireproofing system materials and.
- B. Provide manufacturer's data sheets with complete description of all components, catalog numbers, specific details of applicable U.L. listings, and detailed line drawings of fireproofing methodology to be used for each type of penetration.

PART 2 - PRODUCTS

2.1 MANUFACTURE

- A. Concrete Inserts: Grinnell, Kindorf, Unistrut, B-Line or Hohmann & Barnard.
- B. Drilled Anchors: All metal; heavy duty, non-caulking, expansion bolt anchor. Minimum size used shall be ¼" machine thread.
- C. Metal Framing Channel: 1-5/8" x 1-5/8", 12 Gauge. Use appropriate fittings of same manufacture.

2.2 WOOD BACKBOARDS

- A. Wood backboards shall be ¾" thick, grade B-C, plywood. Paint with gray color fire-retardant paint.
- B. Use backboards only in interior spaces and sized as indicated on the drawings.

2.3 NAMEPLATES

- A. Provide engraved plastic equipment nameplates for all switchboards, panelboards, motor control centers, starters, disconnects, primary selector switches, time clock controls, contactors, and transformers.
- B. A circuit nameplate indicating circuit number and the equipment served shall be provided for each feeder in service switchboard, and each branch device in power distribution panels, and motor control centers.
- C. Distribution equipment nameplates shall state equipment designation, ampere rating, voltage and phase, and "fed from (name)".
- D. Nameplates for individually mounted starters, safety switches, etc., shall state load served, circuit number, voltage and phase.
- E. Refer also to Section 262726 for additional requirements pertaining to device labeling.
- F. Refer also to Section 260553 for additional electrical identification requirements, including but not limited to nameplate sizes and colors.

2.4 FIREPROOFING

- A. All fireproofing materials shall be the product of one manufacturer and shall be U.L. listed for the type of application where applied.
- B. Provide caulk, expanding foam, putty, rigid boards, tape and packing as required by the U.L. listing for the type of penetration being fireproofed.
- C. Fireproofing of sleeves, cable trays, troughs, and nipples to be used for low voltage cables shall be indefinitely non-hardening and removable with common hand tools.
- D. Fireproofing for penetrations of floor slabs shall also be waterproof for standing water in a non-fire condition.
- E. Acceptable Manufacturers:
 - 1. Dow Corning
 - 2. Hilti
 - 3. Nelson
 - 4. 3-M
 - 5. Other manufacturers as determined acceptable by the Engineer.

PART 3 - EXECUTION

3.1 SUPPORTS

- A. All work shall be supported from structural elements of the building, except ceiling mounted equipment such as light fixtures, detectors, remote lamps, which shall be supported from ceiling support members independent of ceiling tiles.

- B. Size and spacing of supports shall be determined by the load to be supported such that the working load of supports will not exceed a safety factor of 4:1.
- C. Spacing intervals of supports shall in no case exceed intervals required by applicable codes.
- D. Plastic anchors, non-removable drive-in type expansion anchors are not acceptable.
- E. Work under this division shall not be supported from piping, ducts, or work of other trades, unless specifically noted on the drawings or with the written permission of the Engineer.
- F. Drilled anchors in sides of concrete joists shall be at least 3" from bottom of joist in the vertical plane.
- G. Provide drilled expansion bolt anchors to support all material mounted on masonry construction.
- H. All hardware, nuts, bolts, channel, braces, etc., used on exterior of building shall be galvanized.
- I. Rod supports shall be constructed of minimum 1/4" nominal continuously threaded rod of a continuous length. Use of rod couplings to extend the length of hanger rod shall not be allowed.
- J. Work installed under Division 26 supported from or attached to structural steel members shall not be welded to steel member but shall be attached by clamping a device manufactured specifically for this purpose.
- K. Floor mounted equipment shall be anchored to supporting concrete pad with expansion anchors, minimum 1/2" nominal stud size and vibration isolation where required.
- L. Framework required to support electrical equipment shall be constructed of 1 1/2" x 1 1/2" steel framing channel bolted together with fittings provided by the framing channel manufacturer.

3.2 PAINTING

- A. Provide the following painting under Division 26 in accordance with the requirements of the specification section describing Finish Painting.
 - 1. Plywood backboards – wood primer and finish coat of ASA 61 gray fire-retardant paint.
 - 2. Panelboards, transformers, disconnect switches and exposed conduits that are a part of the life safety distribution system – primer (on conduits only) and one coat of red enamel.
 - 3. Color of all field paint shall be as directed by owner.
- B. The vendor for painting furnished under Division 26 shall be primary painting subcontractor being utilized by the general contractor.

3.3 WOOD BACKBOARDS

- A. Unless otherwise noted on the drawings, backboards shall be 8'-0" high by the width shown on the drawings.
- B. Backboards shall be attached to supporting structure with 3/8" expansion anchors or toggle bolts with fender washers placed a maximum of 48" on center on all sides of backboard.

3.4 CONCRETE

- A. Provide 3000 PSI concrete where concrete work is required to support equipment furnished under Division 26, such as for equipment pads, lighting standard bases, and concrete-encased duct banks. Refer to drawings and other sections for locations where concrete is required.
- B. Exposed surfaces of concrete placed under this section shall be hand rubbed and all edges shall have 1" chamfer.

3.5 EQUIPMENT PADS

- A. Provide 4" high concrete pads for all floor mounted electrical distribution equipment, including switchboards, and elsewhere as specifically noted on the drawings.
- B. Concrete pads for switchgear, switchboard motor control centers and UPS equipment shall be level to within 1/8" from front to back and from side to side. Provide (2) embedded steel "U" channels; 4" W X 1 1/2" H x 0.25" T, inverted and flush with the top of the pad. Channels shall be at the front and back of the pad located as directed by the equipment manufacturer, to provide a level base for the equipment.
- C. Anchor equipment in accordance with seismic study.

3.6 EQUIPMENT OF OTHER TRADES

- A. Motors, heaters, and other utilization apparatus shall be mounted by the trade which furnished the apparatus.
- B. Provide all power wiring and connections for all electrically operated equipment. Power wiring includes wiring through any line voltage control devices, such as thermostats and manual starters.
- C. Phase connections of motors shall provide proper motor shaft rotation.
- D. Starters and contactors furnished under other divisions, except those furnished as an integral part of the equipment, shall be installed under this division.

3.7 EQUIPMENT CONNECTIONS

- A. Connections to motors, transformers, duct heaters and other vibrating equipment shall be made with a short length of liquidtight flexible conduit, minimum 18", installed in a manner to permit movement of equipment.
- B. For floor-mounted equipment, which is fed overhead and not located adjacent to a wall or column, provide a rigid conduit standpipe from floor to ceiling with a floor flange. Provide appropriate cast conduit "tee" fitting in standpipe for connection of equipment.

3.8 MISCELLANEOUS WORK

- A. Perform all excavating, backfilling, cutting and repairing required for work included in this division.
- B. Protect all work from damage and from entry of concrete, moisture, and other foreign material.

3.9 FIREPROOFING

- A. All penetrations of fire rated walls, slabs, partitions, and ceilings shall be fireproofed with a U.L. listed system that will maintain the original fire rating of the penetrated structure.
- B. Initial fireproofing of sleeves, cable trays and wireways for low voltage cable shall not be installed until cables are installed or until required for issuance of certificate of final inspection, whichever is earlier.

3.10 MULTI-WIRE BRANCH CIRCUITS

- A. Each multi-wire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates.
- B. Combining of circuits into a multi-wire branch circuit is not permissible except where specifically indicated on the drawings.

END OF SECTION

**SECTION 26 0519
600 VOLT BUILDING WIRE AND CABLE**

PART 1 - GENERAL

1.1 SCOPE

- A. This section covers:
 - 1. Building Wire
 - 2. Flexible Cords
- B. Wires and cables used with special systems are specified with the respective system.

1.2 SIZE REFERENCE: AWG EXCEPT AS NOTED.

1.3 QUALITY ASSURANCE

- A. All wire and cable shall be delivered to the jobsite in original unbroken packages, cartons or reels, with the manufacturer's name, UL label, and characteristics of the product plainly visible.
- B. Wire or cable with defective or damaged insulation or jackets shall not be installed. Where damage, such as cuts, gouges, or slices, is discovered in the insulation or jacket while being installed, the damaged wire or cable shall be removed, and replaced. Field taping or other repair of damaged wire or cable is not acceptable.

1.4 SUBMITTAL DOCUMENTS

- A. Provide for all wire, cable, and accessories.
- B. Documents shall plainly indicate the construction of the product, illustrating compliance with all requirements of Part 2, "Products".

PART 2 - PRODUCTS

2.1 BUILDING WIRE

- A. Conductors:
 - 1. Material: copper, 98% conductivity.
 - 2. Construction:
 - a. AWG 10 and AWG 12: solid only
 - b. AWG 8 and larger: stranded unless otherwise detailed on the drawings.
 - c. AWG 14 and smaller: stranded (control use only).

B. Insulation:

1. Type THWN/THHN, dual-rated.
2. Type XHHW: for underground secondary service entrance.
3. Type SFF: for wiring inside of luminaries.
4. Type SIS: for control wiring inside switchboards

C. Voltage Rating: 600

D. Color Coding:

1. Unless contrary to requirements of local codes, the following color code shall apply:

<u>120/208 volts</u>	<u>480/277 volts</u>
Phase A – black	Phase A – brown
Phase B – red	Phase B – orange
Phase C – blue	Phase C – yellow
Neutral – white	Neutral – gray
Ground – green	Ground – green

2. Isolated Ground Conductor color code: AWG 10 and smaller: green with yellow stripe in insulation. AWG 8 and larger: continuous green tape and two bands yellow tape adjacent to each other.
3. If local codes require other than these color codes to be used, the local codes shall be complied with.
4. Color code shall be indicated by:
 - a. AWG #10 and smaller: insulation color
 - b. AWG #8 and larger: colored tape applied at all terminations, and junction boxes, pull boxes and manholes.
 - c. Ground conductors shall be color coded along entire length where visible inside boxes and equipment.
5. Entire length of conductor insulation shall be provided with color specific to phase, as indicated above.

E. Accepted Manufacturers:

1. Belden
2. Clifford of Vermont
3. General Cable
4. Pirelli
5. Rome
6. Senator
7. Southwire
8. Triangle
9. West-Penn

2.2 FLEXIBLE CORDS

- A. 300 Volt – Type SJO with copper conductors
- B. 600 Volt – Type SO with copper conductors
- C. Use only where indicated on the drawings.

2.3 600 VOLT ACCESSORIES

- A. Conduit wedges: 0-Z/Gedney Type “S”
- B. Terminations, power connections, splices, taps:
 - 1. Splices: Compression type, copper, insulated with heat shrink sleeves.
 - 2. Taps #8 and larger: Compression type copper or copper alloy with snap-on insulation cover designed for the specific tap. Insulation displacement type fittings are not acceptable.
 - 3. Taps #10 and #12: twist-on insulated spring type connectors or squeeze-on insulated connector.
 - 4. Terminations: feeder cable to bus bar: copper or copper alloy compression lug, two bolt hole tongue if mounting space allows.
 - 5. Terminations: feeder cable to device or other condition where compression lugs mechanically will not fit: copper alloy mechanical lug, T&B “Locktite” series.
 - 6. Accepted Manufacturers:
 - a. Burndy
 - b. 0-Z/Gedney
 - c. T&B
 - d. Illsco
 - e. Square D
 - f. Panduit
 - g. Buchanan
 - h. 3M
 - i. Ideal
- C. Terminations: Control Conductors:
 - 1. Compression Lug: insulated.
 - 2. Terminal Strip: barrier style, screw type, suitable for wire size and voltage applied.
- D. Wire Lubricants:
 - 1. Lubricant used shall be certified by conductor manufacturer to be satisfactory for use with the specific conductor insulation.
 - 2. Approved material:
 - a. Ideal “Yellow 77”
 - b. Ideal “Yellow 77 Plus”
 - c. 3M wire pulling lubricant

- E. Wire markers: Permanent, machine printed, self-laminating vinyl.

PART 3 - EXECUTION

3.1 SIZES, QUANTITIES, TYPES

A. Building Wire:

1. AWG 12 minimum, except as noted below.
2. No more than six (6) phase conductors shall be installed in a single raceway.
3. Type THHN/THWN shall be used for all branch circuits, AWG 12 through AWG 8. Conductors shall be stranded, unless otherwise noted on the drawings. Where stranded wire is to be connected to wiring devices or other equipment whose terminals are not rated for use with stranded wire, "Stakon" type terminals shall be used on the wire.
4. Conductors larger than AWG 8 installed above grade shall be Type THHN or THWN. Where installed in conduit run below grade, shall be type THWN or XHHW.
5. Where branch circuit conductors enter the wiring compartment of lighting fixtures, the insulation used on that segment of the branch circuit shall be UL listed for application at the temperature that will be encountered in the fixture.
6. General-purpose control conductors: AWG 14 minimum, stranded, protected by control circuit overcurrent protection rated not greater than or set at the rated ampacity of the conductor.

B. Flexible Cords:

1. AWG 16 minimum
2. Rated for the applied voltage and load
3. Contain full size ground conductor

3.2 INSTALLATION

A. Building Wire:

1. Conductors shall not be pulled in an ambient temperature lower than 15° F.
2. Adequate wire lubricants shall be used to minimize pulling tension.
3. Conductors shall not be bent, either manually or with bending tools, in a manner that puts excessive stress on insulation or causes it to buckle. Avoid bending to a radius less than manufacturers recommended minimum. Conductors with visibly damaged insulation shall be replaced at no additional cost to the Owner.
4. Conductors installed in vertical raceways shall be supported by wedge fittings attached to the conduit on intervals as prescribed by the NEC. Provide suitable sized pull box enclosures as required to contain the support wedges.
5. All terminations of feeder conductors not made directly on device terminals shall be made with compression lugs installed in accordance with the manufacturer's instructions and with a compression tool approved for the terminator used.
6. Feeder conductors shall be individually identified at each end and at all intermediate pull boxes and other accessible locations with feeder designation, source, load, voltage, and phase.

7. General-purpose control conductors and all special systems conductors shall be identified on each end with a unique number or designation. This identification shall be recorded on the contractor's as-built drawings.
- B. Flexible Cords: Shall be installed with cord grip and strain-relief connectors.

3.3 TESTS

- A. Cable Test:
1. Megger test all feeders.
 2. Megger test of all feeders shall be accomplished before energizing circuits. Test shall be phase to phase and phase to ground.
 3. Submit a written tabulation of the results of each test to the Owner's representative for review. Replace any cable with installed insulation resistance of less than accepted industry standards, as defined by U.L. 2556, "Wire and Cable Test Methods" and NETA ATS-2009, "Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems".
- B. Replacement of Conductors
1. Replace conductors, determined by testing as not acceptable, without additional cost to the Owner.

END OF SECTION

**SECTION 26 0526
GROUNDING SYSTEM**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Grounding System: Grounding of all electrical equipment and raceways.
- B. Buried Grounds: Buried ground radials and driven ground rods as indicated on the Drawings.
- C. Miscellaneous grounding, installation of separate ground bus bars and miscellaneous bonding.
- D. Provide all grounding and bonding described herein and as detailed on the drawings.
- E. Provide the services of an approved testing contractor to perform a ground resistance test of the completed grounding system.
- F. The completed grounding system installation is subject to review and acceptance by the Consultant.

1.2 SUBMITTALS

- A. Required for materials and fittings for exterior grounding work.
- B. Documents:
 - 1. Manufacturers data sheets describing each component of the system;
 - 2. Qualifications of the proposed testing contractor.

PART 2 - PRODUCTS

2.1 BUILDING GROUNDING SYSTEM

- A. Raceways for separate ground conductors: Type RNC, Schedule 40 conduit.
- B. Conductors:
 - 1. 98% conductivity copper, solid or stranded, sizes and types as indicated on the drawings.
 - 2. In general, main buried ground conductors shall be bare copper, AWG 3/0, seven-strand.
- C. Connections:
 - 1. Underground or exterior connections shall be exothermic weld between conductors, and between conductors and ground rods.

2. In locations where conductor connects to main structural steel components, exothermic welds shall be used. For connections to light-gauge metals or in other locations where a lug must be used, a 2-hole lug shall be exothermic welded to the grounding conductor.
 3. Lugs shall be 2-bolt tongue, compression type.
 4. Compression Splices and Taps: Tin plated copper.
 5. Water pipe clamps, fence posts, test ground rod: T&B 3900 series or Burndy Type "GAR" Series, cast bronze.
 6. Exothermic welds: Cadweld, Thermaweld or Ultraweld.
 7. Solid conductor to equipment or bus: Exothermic weld lug bolted to equipment.
 8. Flexible copper grounding and bonding jumpers: 0-Z/Gedney Type "FB" series, or Burndy Type "B" Series, rated 190 AMPS, length as required for each application.
 9. Ground Rods: "Copperweld", copper clad steel, 3/4 " diameter, 10' length. Provide sectional rods of same construction where lengths greater than 10 feet are required to be used.
- D. Non-Oxide Compound:
1. "NO OXID A" compound as manufactured by Sanchem Chemical Company, Chicago Illinois.

PART 3 - EXECUTION

3.1 BURIED GROUNDS

- A. Unless otherwise indicated, ground rods shall be driven into undisturbed earth.
- B. Tops of rods and all horizontal buried conductors shall be minimum 30" below finished grade.
- C. Minimum lateral distance from building footings shall be 24".
- D. Installed grounding work below grade shall not be covered until reviewed by the testing contractor.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Separate Grounding Conductor: All branch circuits and feeders operating at higher than 50 volts to ground shall have an insulated equipment ground conductor, green color, sized in accordance with the National Electrical Code.
- B. Raceway Grounds: Other circuits shall utilize the raceway as the equipment ground conductor except where noted otherwise.
- C. Single grounding conductors, or RNC conduits containing single ground conductors, shall not be totally encircled by ferrous metal. Use nylon bolts in pipe hangers or in Unistrut conduit straps.
- D. All grounding connections shall be subject to inspection and review by the testing contractor and the Consultant. Provide 72 hours advance notice for scheduling review.

- E. Provide specified “non-oxide” compound between mating surfaces on all equipment bonding connections where mechanical connections are utilized in lieu of exothermic welds.
- F. Ground conductors shall be installed using long radius bends, minimum 12” radius, and shall maintain a downward or horizontal direction. U-bends or tight radius bends less than 90 degrees are not acceptable.
- G. All connections to the buried ground ring conductor shall be exothermic welded including connections to ground rods.
- H. Bond connections to equipment shall utilize exothermic weld lugs, 2-bolt tongue type, attached using machine screw thread type bolts where exothermic welds cannot, or should not, be utilized.
- I. Provide combination “Do Not Disconnect” and “Destination” tags at all interior bonding and grounding connections. Tags shall be green plastic laminate with white letters. Letters shall be minimum ¼” high. Attach all tags using Nylon cable Ty-raps.

3.3 MOTOR GROUNDING

- A. Shaft Grounding:
 - 1. All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro fibers to discharge damaging shaft voltages away from the bearings to ground.
 - 2. All motors up to 100 horsepower shall be provided with one shaft grounding ring installed either on the drive end or non-drive end.
- B. High-Frequency Bonding:
 - 1. All motors operated on variable frequency drives shall be bonded from the motor foot to the system ground with a high frequency ground strap made of flat braided, tinned copper with terminations to accommodate motor foot and system ground connection.

3.4 GROUND TESTING

- A. Testing of grounding systems and made ground electrodes shall be performed by an approved testing company.
- B. Measurements shall include the earth resistivity and resistance of the grounding electrode system.
- C. Record ambient temperature; date; time; condition of soil (wet or dry). Where available, record approximate water table level (as obtained from local geologists, special core drilling is not required); type of earth materials; earth resistivity.
- D. Provide written record of resistance readings and all other information listed above. Include on “Record Drawings”.

- E. Notify Owner if ground resistance is above 25 ohms.

END OF SECTION

**SECTION 26 0533
CONDUIT**

PART 1 - GENERAL

1.1 GENERAL

- A. This section describes conduit and related fittings. Other raceway types are specified in other sections.
- B. Boxes and other raceway accessories are specified in other sections.

1.2 SIZE

- A. Minimum conduit size shall be ½"; Exception: 3/8" flexible metal conduit or Type AC or MC is permitted for flexible connections to lighting fixtures and fire alarm devices.
- B. Conduit size may be increased to facilitate pulling of conductors.

1.3 COORDINATION WITH WORK OF OTHER TRADES

- A. Coordinate the conduit layout with the work of other trades. Conduits shall be located to avoid interference with equipment that requires access, maintenance, adjustment, or repair. Conduits shall not restrict the required working clearance around such equipment.
- B. Conduits feeding, or connecting to, equipment provided by other trades shall not be installed until such equipment is installed or until the trade providing the equipment furnishes specific rough-in instructions.
- C. Conduits shall be concealed, unless otherwise indicated.

1.4 SCOPE OF CONDUIT WORK SHOWN ON THE DRAWINGS

- A. The conduit layout indicated on the drawings is schematic and is not intended to show the exact location of conduits unless specifically dimensioned. Locate conduit as required by the architectural and structural details of construction and by the coordination with the work of other trades.
- B. Provide all fittings, offsets, supports, pullboxes and other components of the conduit system as required for a complete raceway system.

1.5 QUALITY ASSURANCE

- A. The conduit shall be new, of uniform quality and appearance, and marked with U.L. listing and name of manufacturer.

- B. All seams shall be smooth, without splits, clean, and with threads protected when delivered to or stored on site.
- C. Provide fittings designed and U.L. listed for use with the specific wiring method used.
- D. Set-screw fittings are NOT allowed.

1.6 SUBMITTAL DOCUMENTS

- A. Provide submittal documents for the following:
 - 1. PVC raceways and fittings
 - 2. EMT fittings
 - 3. Conduit bushings
 - 4. Flexible conduit and fittings

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT (TYPE RMC)

- A. Manufacturers:
 - 1. Allied Tube & Conduit Corp.
 - 2. Jones & Laughlin
 - 3. Pittsburgh-Standard
 - 4. Republic
 - 5. Triangle Wire & Cable, Inc.
 - 6. Wheatland Tube Co.
 - 7. Youngstown
 - 8. ETP
 - 9. Robroy Industries, Inc.
- B. Material: Full weight, steel, standard size, hot dipped galvanized outside, galvanized or coated inside, threaded ends.
- C. Fittings:
 - 1. Couplings: Continuous threaded, furnished by the manufacturer with conduit. For IMC, ETP "Uni-Swivel" couplings are acceptable.
 - 2. Threaded joint compound: Fel-Pro C5A.
 - 3. Terminations (dry locations): Double locknuts with insulated throat, metallic grounding bushing, 0-Z/Gedney type "BLG".
 - 4. Terminations (wet locations): Watertight hubs, 0-Z/Gedney Type "CHM", or conduit hubs integral with equipment.

2.2 INTERMEDIATE METAL CONDUIT (TYPE IMC)

- A. Manufacturers: same as for RMC

- B. Material: Lightweight steel, standard size, hot dipped or electro-galvanized zinc outside and galvanized or enamel coated inside, threaded ends.
- C. Fittings: same as for RMC

2.3 RIGID NON-METALLIC CONDUIT (TYPE RNC)

- A. Manufacturer:
 - 1. Carlon, Division of Lamson & Sessions Co.
 - 2. Sedco
 - 3. Centex, Inc.
 - 4. Heritage Plastics
 - 5. Certainteed Corp.
- B. Material: PVC Schedule 40, unless otherwise indicated, rated for use with 90°C conductors.
- C. Where PVC being run under slabs, or grade, turns up through the slab, or above grade, the elbow and vertical section of conduit from the elbow to the termination of the conduit shall be RMC, or IMC, as protection against the exposed conduit being damaged.
- D. Accessories: Fittings, couplings, cement, and other accessories shall be of the same manufacture as the PVC conduit that they are used with.

2.4 ELECTRICAL METALLIC TUBING (TYPE EMT)

- A. Manufacture: same as for RMC.
- B. Material: Thin-wall steel, galvanized outside, coated inside, threadless.
- C. Fittings:
 - 1. For EMT (Sizes 1.25" and smaller):
 - a. Couplings: All steel, compression style, concrete tight where installed in concrete, Raco, T&B, Midwest, or Steel City, O-Z/Gedney
 - b. Connectors: All steel, compression style, with nylon throat; Raco, T&B, Midwest, or Steel City.
 - 2. For EMT (Sizes 1.50" and larger):
 - a. Couplings: All steel, compression style, of same manufacture.
 - b. Connectors: All steel, compression style, of same manufacture, and insulated throat, metallic grounding bushing, O-Z/Gedney Type "BLG".

2.5 FLEXIBLE METAL CONDUIT (TYPE FMC)

- A. Manufacture:

1. AFC Cable Systems, Inc.
 2. Alflex
 3. Electri-Flex Co.
 4. Steelflex Electro Corp.
- B. Material: galvanized steel, Continuous single interlocking strip.
- C. Fittings: T&B "Tite-Bite" series, Midwest Fittings.

2.6 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (TYPE LFMC)

- A. Manufacture: same as for FMC.
- B. Material: Flexible metallic conduit with PVC jacket, type "UA", with integral copper grounding conductor suitable for use as equipment grounding conductor.
- C. Fittings:
1. Material: Steel, or malleable iron, liquid-tight connector with insulating throat liner (use bushing above 1.25").
 2. Manufacture: T&B, Midwest Fittings, O-Z/Gedney.

2.7 EXPANSION FITTINGS AND ACCESSORIES

- A. Expansion fittings:
1. For conduit not embedded in concrete while passing across building expansion joint, provide O-Z/Gedney type AX for GRC and IMC or type TX for EMT. Provide bonding jumper.
 2. For conduit embedded in concrete while passing across building expansion joint, provide O-Z/Gedney type DX expansion joint or type AXDX if required by the degree of expansion possible.
- B. Seals for exterior wall below grade penetrations:
1. Cast-in-place type: O-Z/Gedney Type "WSK".
 2. Cored openings: O-Z/Gedney Type "CSMI" and Type "CSMC".
 3. Non-shrink grout where indicated on the drawings and where acceptable to the Architect.
- C. Conduit bodies:
1. Used for pulling conductors: Crouse-Hinds LBD series through 2.00" and LBNEC Series 2.50" and above.
 2. Used for motor connection: Crouse-Hinds conduit "T" series.
- D. Pull strings for empty conduits shall be equal to Greenlee 430 poly pull line.

PART 3 - EXECUTION

3.1 GENERAL

- A. Conduit supports and seismic bracing is specified in other sections.
- B. Run exposed conduits parallel or perpendicular to structural elements.
- C. Two or more raceways run together shall be installed on trapeze type gang hangers. Such raceways assemblies shall be run parallel or perpendicular to structural elements.
- D. Where bends are made in a rack of exposed conduits, field bent concentric elbows shall be used.
- E. All wiring shall be installed in conduit, unless plenum rated cable is specified in other sections to be installed without conduit or, unless the wiring is shown to be in a wireway or cable tray.
- F. Unless specifically noted on the drawings all raceways shall be concealed in walls, floor slabs, topping slab on floor, or in ceiling plenums.
- G. Apply threaded joint compound on all Type RMC and Type IMC threaded joint connections.

3.2 SCHEDULE

- A. Unless otherwise required, provide RMC or IMC for the following applications:
 - 1. Where subject to damage.
 - 2. Exposed on exterior of building.
 - 3. Exterior circuits under roadways.
- B. Provide EMT in dry locations only for the following applications:
 - 1. Concealed work in walls, and ceiling plenums.
 - 2. Branch circuit feeder wiring not otherwise required to be run in RMC or IMC.
 - 3. Signal or communication raceways (other than underground)
- C. Provide RNC PVC for the following applications:
 - 1. Concrete encased duct banks where specifically indicated.
 - 2. Single grounding conductors as indicated and where not run in plenum spaces.
 - 3. Concealed work in slabs.
- D. Flexible conduit is permitted only where concealed above suspended ceilings for connections of light fixtures, tele-power poles, and similar equipment and shall not exceed 3'-0" length. Light fixture whips may be 6'0" in length.
- E. Liquid-tight flexible metal conduit (LFMC) shall be used for all connections to vibrating equipment, such as motors and transformers, and where flexible conduit is indicated on the drawings, except as noted above. Use Type FMC in plenum spaces.

3.3 INSTALLATION

- A. Conduits embedded in slabs shall have a minimum of 1" cover of concrete on all sides. Outside diameter of conduit shall not exceed 1/3 of the slab thickness and shall not be larger than 1.25".
- B. All threaded conduits shall be terminated with specified bushings.
- C. Paint all underground steel conduits with one coat of Rustoleum 5269 primer and one coat of Rustoleum 5282 acrylic industrial enamel. Touch up all wrench marks and other defects.
- D. Underground conduits shall be a minimum of 24" below final grade.
- E. Conduit joints:
 - 1. Ream end of conduit smooth.
 - 2. Conduit ends shall meet in coupling.
 - 3. Provide unions where required, of the Erickson Type.
 - 4. Provide joint compound on the male threads of RMC and IMC conduit.
- F. Use double locknuts at threaded conduit terminations.
- G. The conduit system shall be left free of all debris, water and foreign material. Plug or cap all conduits with exposed ends to prevent entrance of concrete or other foreign material. Pull a cleaning swab through all conduits prior to pulling conductors.
- H. Conduits run parallel to, or crossing hot pipes, shall not be closer than 0'-6" to hot pipe.
- I. Anchors or supports in waterproof walls shall be of the type and methodology directed by the architect.
- J. Empty EMT raceways shall be terminated with connectors, and if over 1.25", specified bushings.
- K. Raceways in accessible ceiling plenums shall not be installed closer than 8" to ceiling.
- L. Groups of two or more conduits turned out of a slab shall be neatly arranged parallel to the adjacent wall and evenly spaced with at least (1) inch separation.
- M. Conduit passing through walls below grade shall be run through specified fittings in the wall and shall be sealed to be waterproof.
- N. All threaded joints in rigid conduit shall have pipe compound applied to the male thread only, to be watertight where buried below grade and not encased in concrete.

3.4 ACCESSORIES

- A. Pull wires: provide nylon pull wire in all empty conduits and at all data and telephone outlet locations.
- B. Expansion fittings: provide at all building expansion joints.

- C. Fire seals: provide where conduit passes through a floor slab (other than slab on grade) and where conduit passes through fire-rated masonry walls, unless cast in place.
- D. Install specified seals for exterior wall below grade for penetrations of conduits.

3.5 IDENTIFICATION

- A. All exposed conduits 2 inches and larger shall be identified with markers 20 feet on center. Also refer to Section 260553 – Electrical Identification.
- B. Markers shall be permanent, plastic-sheet conduit markers extending 360 degrees around conduit.
- C. Marker shall identify voltage and function of conductors in conduit and be minimum length of 8 inches.

END OF SECTION

**SECTION 26 0534
BOXES**

PART 1 - GENERAL

1.1 SCOPE

- A. This section covers pull boxes, outlet boxes, and junction boxes.
- B. Refer to Section 262726, WIRING DEVICES for additional requirements for outlet boxes for wiring devices.

1.2 APPLICATIONS

- A. All splices, pull boxes, taps, connections, devices, etc., shall be installed using boxes of the appropriate type, designed and approved for the intended purpose.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Box sizes specified are minimums, and shall be increased where required by code due to the number of conduit entries, conductors, devices, or taps in the box.
- B. All boxes shall be made of galvanized sheet steel, of code gauge thickness, but no less than 1/16" thick or 14 Gauge.
- C. Outlet box covers shall be attached by means of machine screws. Self-tapping sheet metal screws are not acceptable.

2.2 MANUFACTURE

- A. Outlet boxes: Steel City, Appleton, Raco
- B. Cast boxes: Crouse-Hinds, Appleton

2.3 SCHEDULE

- A. Schedule indicates box type; select actual box and plaster ring to suit actual conditions:

<u>USE</u>	<u>BOX</u>	<u>COVER</u>
Recessed device outlet	RACO 683	RACO 770
Recessed tele/data outlet	RACO 683	RACO 770
Recessed wall mounted fixture	RACO 683	RACO 767
Flush concrete outlet	RACO 272	RACO 893
Flush concrete junction	RACO 272	RACO 892

Junction box above ceiling	RACO 257	RACO 832
Exposed device outlet	C/H "FS"	C/H DS32
Exposed fixture outlet	C/H "GRFX"	-----
Flush ceiling fixture	RACO 683	RACO 767

2.4 SPECIALTIES

- A. Boxes installed in concrete shall be UL listed for such use.
- B. Through-wall boxes are not acceptable.
- C. Provide 3/8-fixture stud and box supported from structure when required by weight of fixture being supported.
- D. Junction boxes installed above ceilings shall be plenum type.

2.5 PULL BOXES AND JUNCTION BOXES

- A. In dry locations, boxes shall be galvanized sheet steel, minimum 12 gauge, with machine screw covers, and welded construction. Welds shall be slag-free and cold galvanized.
- B. In damp locations or outdoors, unless otherwise shown on the drawings, boxes in steel raceway runs shall be galvanized cast iron, with gasketed covers and conduit hubs, or drilled and tapped. Boxes in Type RNC PVC raceway runs shall be PVC with gasketed cover.
- C. All boxes shall be rated for their application, such as sidewalk, or light vehicle traffic.
- D. Provide insulated cable support racks in feeder pull boxes where conductor length exceeds 48" inside pullbox.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to other sections for mounting heights of boxes for devices and equipment.
- B. Boxes shall be located clear of other trades, and shall be accessible.
- C. Coordinate the exact location of ceiling outlet boxes and boxes concealed above ceilings, with ductwork and piping so that the box will be accessible.
- D. All required pull boxes are not indicated on the drawings. Provided boxes as determined by actual field installation and as required for a complete installation.
- E. Using a permanent, waterproof, wide black marker, clearly label covers of all branch circuit junction boxes, and smaller pull boxes, with panel and circuit number of circuits contained in, or passing through, the box.

- F. Branch circuit and feeder junction and pull boxes used with emergency life-safety feeders and circuits shall be painted red.
- G. Provide engraved "Iamicro" nameplate on cover of each major feeder pull, or junction, box as specified under Section 260553 - "Electrical Identification".

3.2 INSTALLATION

- A. Boxes shall be securely anchored in place, and shall be supported independent of the raceway system.
- B. Boxes installed in poured concrete shall be anchored to the formwork and protected against entry of any concrete.
- C. Boxes shall be set square and plumb with building elements.
- D. Outlets for ceiling mount fixtures shall be rigidly supported from the grid or structure with an assembly manufactured for this purpose.

END OF SECTION

**SECTION 26 0553
ELECTRICAL IDENTIFICATION**

PART 1 - GENERAL

1.1 SCOPE

- A. Identification nameplates and labels.
- B. Wire and cable identification markers.
- C. Conduit identification markers

1.2 SUBMITTALS

- A. Product Data: Provide catalog data for nameplates, labels, and markers.
- B. Manufacturer's application conditions and limitations of use including, instructions for storage, handling, protection, examination, preparation, and installation of product.

PART 2 - PRODUCTS

2.1 NAMEPLATES AND LABELS

- A. Engraved three-layer laminated plastic nameplate with minimum 1/4" height letters.
- B. Equipment connected to non-essential supply (commercial power only) commercial source: Black letters on white background.
- C. Equipment connected to the essential supply (commercial power or generator power via transfer breakers or a transfer switch): White letters on red background.
- D. Locations:
 - 1. Main Service and Distribution equipment enclosures and over-current devices.
 - 2. Electrical distribution equipment enclosures.
 - 3. Transformers
 - 4. Motor Control Devices and Contactors.
 - 5. Disconnect switches.
 - 6. Communication cabinets.
- E. Labels:
 - 1. Locations required:
 - a. All motors.
 - b. All field equipment fed from 120/208 V power source.
 - c. All field equipment such as motors, control stations, etc.

- d. All lighting switches and receptacles in unfinished areas.
- F. Provide engraved plastic equipment nameplates for all switchboards, panelboards, motor control centers, starters, disconnects, primary selector switches, time clock controls, contactors, and transformers.
- G. Nameplate wording shall be coordinated with final equipment identification nomenclature and approved by the owners' designated representative prior to installation.
- H. Letter Size:
 - 1. 1/4-inch letters: Identify individual equipment, and loads.
 - 2. 1/2-inch letters: Identify major electrical equipment and panelboards.

2.2 WIRE AND CABLE MARKERS

- A. Description: Non-ferrous identify tag or shrink type label.
- B. Locations: Each cable feeder, power circuit, and conductor in vaults, manholes, gutters, pull boxes, starters, outlet and junction boxes, control panels, panelboards, switchboards, etc., and each load connection.
- C. Legend: Each tag or label shall be typewritten with description listed below.
 - 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
 - 2. Control Circuits: Control wire number indicated on schematic and interconnection diagrams.

2.3 CONDUIT MARKERS

- A. Location: Furnish vinyl markers for each exposed 2.00" or larger conduit longer than 6 feet for power circuits or exposed Type MC Cable with 3/0 or larger conductors longer than 6 feet.
- B. Spacing: Adjacent to each termination at equipment and pull boxes and intermittently at 20 feet on center.
- C. Color: Match existing color-coding scheme in the facility. Where color-coding does not already exist, then use the following color-coding on new work.
 - 1. 480-volt system: Orange color and black stencil, voltage in 1/2" black letters. At the source end, also indicate the load served in 1/2" black letters. At the load end, also indicate the circuit source identification in 1/2" black letters. At intermediate points, also identify both the circuit identification and load in 1/2" black letters.
 - 2. 208-volt system: White color and black stencil, voltage in 1/2" black letters. At the source end, also indicate the load served in 1/2" black letters. At the load end, also indicate the circuit identification in 1/2" black letters. At intermediate points, also identify both the circuit identification and load in 1/2" black letters.

2.4 UNDERGROUND WARNING TAPE

- A. Description: 4-inch-wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines.
- B. Location: Along length of each underground conduit or direct buried cable or duct bank.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive nameplates and labels.

3.2 INSTALLATION

- A. Install nameplate and label parallel to equipment lines.
- B. Secure nameplate to equipment front using screws.
- C. Secure nameplate to inside surface of door on panelboards that are recessed in finished wall locations.
- D. Install conduit markers per Article 2.3.
- E. Stencil conduit markers or use adhesive letters or order pre-labeled. Handwritten entries that are neat and legible and not smeared are acceptable. Any conduit markers that are determined not to be neat, legible, and free from smears shall be replaced to the satisfaction of the Architect.
- F. Identify underground conduits and direct buried cables using underground warning tape. Install one tape per trench at 3 inches below finished grade and at 12 inches above top of conduits.
- G. Use Scotch +35 marking tape to color-code the phase conductors equal and larger than AWG #6.
- H. In a high delta service, the phase with the highest voltage to ground shall be orange.
- I. For other conductor color-coding, see Section 260519 - Building Wire and Cable.

END OF SECTION

**SECTION 26 2400
NEW OVERCURRENT DEVCIES IN EXISTING EQUIPMENT**

PART 1 - GENERAL

1.1 SCOPE

- A. This section covers the installation of new overcurrent protective devices in existing equipment.

1.2 DESCRIPTION OF WORK

- A. Provide new overcurrent protective devices, hardware and associated components as required for a complete installation in existing switchboards and panelboards as indicated on the plans.

PART 2 - PRODUCTS

2.1 AVAILABILITY OF DEVICES

- A. Where a device is obsolete and the manufacturer does not offer an equivalent replacement device, provide written notice.
- B. New device voltage and fault current interrupting ratings (SCCR) shall equal, or exceed, existing device ratings unless otherwise noted elsewhere in the specification or on the drawings.

2.2 HARDWARE

- A. Bus bars, draw-out and plug-in assemblies, connectors, adapters, lugs, and other hardware shall be of the same type and manufacture as existing equipment.
- B. New closure panels and doors shall match existing equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Extend, modify, brace and install all new busing to match existing busing.
- B. All hardware, doors, panels and closure plates shall be mounted in alignment with existing equipment.
- C. Provide engraved nameplates on all new circuits in switchboards and in power distribution panelboards.

- D. Provide new typewritten directory in branch circuit lighting and receptacle panelboards where circuits have been modified under this scope of work.

3.2 TESTING

- A. All costs incurred for testing shall be included under Division 26.
- B. Test and calibrate all new circuit breakers furnished under this contract and “spare” breakers scheduled to be placed into service, prior to acceptance of the building. This requirement shall apply to breakers rated 100 amp and larger.
- C. Tests shall be conducted by a NETA certified and approved independent testing company per NETA recommendations and in accordance with NETA Standard Practices.
- D. In general, tests shall include the following:
 - 1. Determine proper operation of circuit breaker trip devices.
 - 2. Determine trip ratings or settings are correctly adjusted
 - 3. Determine control and interlock devices performed as specified.
 - 4. Determine electrical resistance across contact surfaces in switches, circuit breakers and bus way are acceptable.
 - 5. Torque all bolted connections
- E. These tests shall not alter the contractor’s guarantee of the equipment. All work and materials found to be in non-compliance shall be replaced and re-tested by the contractor without additional cost to the Owner.
- F. Provide (3) copies of bound test reports, bound and included in the closeout documentation.

END OF SECTION

**SECTION 26 2700
MISCELLANEOUS DISTRIBUTION EQUIPMENT**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes disconnect switches, separate individually-enclosed circuit breakers, electronic time clocks, lighting contactors, photoelectric control devices, and fuses for other than devices furnished with integral current-limiting fuses, such as fused circuit breakers and motor circuit protectors.
- B. Spare fuses of all types are included in this section.
- C. Provide required fuses, including spare fuses, for all fusible equipment furnished under this division.

1.2 NAMEPLATES

- A. Provide engraved "lamicore" nameplates for all disconnect switches, time clocks, contactors, and individually enclosed circuit breakers, indicating the equipment served. Refer also to Section 260553, Electrical Identification.

1.3 SPARE FUSES

- A. Provide (3) three spare fuses of each type and rating for all power and control fuses, including current-limiting fuses furnished as an integral part of fused circuit breakers or motor circuit protectors.

1.4 SUBMITTAL DOCUMENTS

- A. Required for all equipment specified by this section.
- B. Circuit breaker submittal shall indicate device ratings, including interrupting capacity, dimensions of enclosure, and wire bending space.

1.5 OPERATION AND MAINTENCE MANUALS

- 1. Provide record copy of all submittal documents and assemble as identified in another section.
- 2. Provide two (2) copies of any software required to configure the lighting control system(s).

PART 2 - PRODUCTS

2.1 GENERAL

- A. All devices shall be UL labeled.

2.2 FUSES

- A. Manufacturer:
 - 1. Bussman
 - 2. Ferraz-Shawmut
 - 3. Little-Fuse
- B. Fuses applied on circuits operating at 250 Volts or less shall be 250 Volt rated.
- C. Fuses applied on circuits operating at less than 600 Volts and more than 250 Volts shall be 600 Volt rated.
- D. All fuses shall have an interrupting capacity of 200,000 amps, RMS symmetrical, at rated voltage.
- E. Fuses for transformer feeders and motor branch circuits shall be dual-element time delay, current-limiting, Class J for 600 Amp and smaller, Class L for larger than 600 Amp.
- F. Fuses for feeders, control circuits, and other loads shall be fast acting, current limiting, Class J for 600 Amp and smaller, Class L. for larger than 600 Amp.

2.3 DISCONNECT SWITCH (SAFETY SWITCH)

- A. Manufacturer:
 - 1. Cutler-Hammer
 - 2. General Electric
 - 3. Siemens
 - 4. Square D
- B. Shall be of the fusible or non-fusible type, as indicated on the drawings.
- C. Shall be heavy duty, quick-make, quick-break, HP rated, hinged cover dual interlocked with switch handle and with external interlock defeat mechanism, with provision for handle and door padlocking.
- D. In dry locations shall be Type NEMA 1 enclosed.
- E. In damp locations, or outdoors, shall be Type NEMA-3R, enclosed, except where the applied use requires an alternate Type NEMA enclosure rating.

2.4 DOUBLE-THROW DISCONNECT SWITCH

- A. Manufacture:
 - 1. Cutler-Hammer
 - 2. Siemens
 - 3. Square D
- B. Shall be of the fusible or non-fusible type as indicated on the drawings.
- C. Shall be heavy duty, quick-make/quick-break, load-make/load-break rated, HP rated, hinged cover dual interlocked with switch handle and with external interlock defeat mechanism, with provision for handle and door padlocking.
- D. Switch handle shall have padlocking provisions in all (3) three switch positions and external interlock defeat mechanism.
- E. Installed in dry locations: Type NEMA-1 enclosed.
- F. Installed in damp locations or outdoors: Type NEMA-3R enclosed, except where the applied use requires an alternate Type NEMA enclosure rating.
- G. Provide separate ground bus. Provide insulated neutral bus where the scheduled feeder contains a neutral conductor.
- H. Provide lugs sized for actual feeder conductors where standard factory lugs are not suitable.

2.5 INDIVIDUALLY ENCLOSED CIRCUIT BREAKERS

- A. Manufacturer:
 - 1. Cutler-Hammer
 - 2. General Electric
 - 3. Siemens
 - 4. Square-D Company
- B. Breakers shall be of appropriate frame size for the indicated trip setting, and rated for the applied circuit voltage. Fault current interrupting rating of each breaker shall be as noted on the drawings, minimum 42,000 A.I.C.R.
- C. Installed in dry locations: NEMA-1, enclosed.
- D. Installed in damp locations or outdoors: NEMA-3R enclosed, except where the applied use requires an alternate rating.

2.6 COMBINATION TIME SWITCH/PHOTOCONTROL

- A. Two-channel digital time switch with 30A SPDT contacts, capable of 20 set points, automatic Daylight Savings Time and Leap Year compensation, and LCD display.

- B. Unit shall have astronomic option with offset up to 4 hours and 59 minutes, before or after sunrise.
- C. Real time clock shall be retained by super capacitor for 100 hours.
- D. Unit shall be capable of manual override ON or OFF either to next scheduled event or permanently.
- E. Provide electronic light sensor which can be mounted up to 1000 feet from the controller.

2.7 TIME SWITCH

- A. Two-channel digital time switch with 30A SPDT contacts, capable of 20 set points, automatic Daylight Savings Time and Leap Year compensation, and LCD display.
- B. Unit shall have astronomic option with offset up to 4 hours and 59 minutes, before or after sunrise.
- C. Real time clock shall be retained by super capacitor for 100 hours.
- D. Unit shall be capable of manual override ON or OFF either to next scheduled event or permanently.

2.8 LIGHTING CONTACTORS

- A. Mechanically held, multi-pole, minimum of (1) one spare pole space. Contacts shall be field convertible with N.O. and N.C. indicators.
- B. Ratings: 30 Amp fluorescent lighting; 20 Amp tungsten lighting.
- C. Enclosure: Type NEMA 1, except where the applied use requires an alternate rating.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount disconnects on building structural elements, or on auxiliary framing, with top at 6'-0" A.F.F. where allowed by surrounding conditions.
- B. Devices shall not be supported from, or mounted to, equipment of other trades unless approved in writing by the manufacturer of that equipment.
- C. Raceways connecting NEMA-3R enclosed devices shall be installed in such a manner as to prevent the entry of water. Raceways shall enter only the bottom of the enclosure.
- D. Provide engraved lamcore nameplate for each disconnect and separately enclosed breaker. Nameplates shall state source of circuit, load served, circuit number, voltage, and phase. Refer to Section 26 05 53, Electrical Identification.

- E. Provide disconnect switches for all motors, HVAC, plumbing equipment, and other electrically operated equipment where not connected by cord and plug, unless fed from a motor control center located in the immediate area of the motor. Disconnect switches shall be fused where equipment manufacturers electrical data label plate states "Maximum Fuse Size", or similar wording.
- F. Mount individual line voltage photoelectric controls on suitable weatherproof box, or suitable cast conduit fitting, in the directional orientation as recommended by the manufacturer. Adjust sensor window for suitable operation at dusk and at dawn

END OF SECTION

**SECTION 262726
WIRING DEVICES**

PART 1 - GENERAL

1.1 SCOPE

- A. This section describes wall switches, occupancy sensors, receptacles, faceplates, and other wiring devices.
- B. Outlet boxes are specified in another section.

1.2 STANDARDS

- A. All devices shall be UL labeled.
- B. All devices shall meet applicable NEMA wiring device standards.
- C. All special-purpose receptacles shall be NEMA Standard configuration.

1.3 SUBMITTAL DOCUMENTS

- A. Submit manufacturer catalog cut sheets of wiring devices specified in this section.

1.4 OPERATION AND MAINTENANCE MANUAL

- A. Provide record copy of device submittal incorporated into the project O&M Manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURE

- A. Switches, receptacles, plates:
 - 1. Arrow-Hart
 - 2. Bryant
 - 3. Hubbell
 - 4. P&S/Legrand
- B. Occupancy Sensors
 - 1. Wall Mounted: passive dual technology type sensor, suitable for single or multi-gang mounting in standard depth wall box.
 - 2. Ceiling Mounted: passive dual technology type sensor, suitable for mounting at ceiling height in suitable outlet box.
 - 3. Manufacturer:

- a. Sensor Switch
 - b. Watt Stopper
 - c. Hubbell
4. Device types and manufacturer series numbers on the drawings are based on Sensor Switch.
 5. Contractor shall be responsible for commissioning of devices for proper operation prior to completion of project and shall provide owner with a typed/written report.

2.2 DESCRIPTION

- A. The color of all devices mounted in finished interior spaces shall be as selected by the Architect.
- B. Switches, receptacles:
 1. Standard wall toggle switches for lighting circuits shall be heavy-duty, 277 Volt, 20 Amp, AC only, nylon, quiet type, with ground bonding screw terminal, Hubbell #HBL1221 Series, back wired using screw and clamp.
 2. Special purpose switches, such as 3-way, double-pole, and 4-way switches shall be similar construction.
 3. Duplex receptacles shall be heavy-duty, 125-volt, 15 Amp, 3-wire grounding, nylon face, with self-grounding attachment, with ground bonding screw terminal, Hubbell #HBL5362 Series, back wired using screw and clamp.
 4. Individual duplex receptacles on separate 20 Amp circuits shall be rated 20 Amp.
 5. Special purpose receptacles shall be of NEMA type indicated, heavy-duty, with nylon face where available.
 6. Wall toggle switches mounted adjacent to wall box dimmers shall be of the same manufacture and appearance as the wall box dimmer.
 7. G.F.C.I. Type receptacles shall be rated 20 Amp, Hubbell #GF5362 Series.
 8. All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles installed in a wet location shall be listed weather-resistant type.
 9. Remote switch with local override:
 - a. 5A, SPST (single pole) – Sentry Switch SS05277, Lithonia SSPL5277, Cooper G5-W
 - b. 5A, SPDT (three-way) – Sentry Switch SS053277, Lithonia SSPL53277, Cooper G5T-W
 - c. 20A, SPST (single pole) – Sentry Switch SS20277, Lithonia SSPL20277, Cooper G20-W
 - d. 20A, SPDT (three-way) – Sentry Switch SS23277, Lithonia SSPL23277, Cooper G20T-W
- C. Device plates/covers for interior application:
 1. Finished Room Areas: As selected by Engineer/Owner.
 2. Utility and Mechanical Room Areas: Nylon cover, color to match devices.
- D. Device plates/covers for exterior exposed outlets:

1. Weatherproof, heavy-duty cast aluminum, "in-use" type where required by the location to be applied, Hubbell #WPxxx Series, or cast iron for FS/FD box mounting.
2. Weatherproof receptacle covers shall be suitable for the specific application.
 - a. 15- and 20-ampere, 125- and 250-volt receptacles installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug is inserted.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to Section 260534, BOXES, for outlet box requirements.
- B. All devices shall be installed in appropriate boxes designed for the purpose, in accordance with manufacturer's directions.
- C. Adjacent outlets of any type, including dimmers and fan speed controls, shall be installed in multi-gang boxes with a single multi-gang faceplate.

3.2 INSTALLATION

- A. Locations, unless otherwise required by local codes or noted on the drawings (dimensions in center):
 1. Switches: 48 in. above finished floor, 4 in. from doorjamb on strike side of door.
 2. Receptacles: 1 ft. 6 in. above finished floor, except where indicated above a countertop.
 3. Telephone and data outlets: 1 ft. 6 in. above finished floor, except where indicated above a countertop.
- B. Grounding: Provide AWG 12, green color, insulated copper ground bonding jumpers for all switches and receptacles, bonded to the grounding screw provision within the box with separate grounding screw or lug.
- C. Device Labeling (applies to branch circuit devices wiring outlets under this section):
 1. Provide adhesive backed label on each wall switch and receptacle device outlet coverplate indicating panelboard served from and circuit number (i.e.: LPA-6).
 2. Labels shall be made on 3/8" or 1/2" inch stock, black color letters with clear background.
 3. Label system shall be Brother "P-Touch" System or equivalent.
 4. Labels shall not be applied until final touch-up painting is complete and covers are permanently mounted.

END OF SECTION