



SECTION 15010 – GENERAL MECHANICAL

PART ONE – GENERAL:

1.01 SCOPE:

- A. The General Conditions and Special Conditions are a part of these specifications.
- B. Drawings and specifications are complementary each to the other and what is called for by either shall be as binding as if called for by both.
- C. Provide all supervision, labor, material, equipment, machinery, plant and any other items necessary for a complete, safe and quietly operating mechanical system.
- D. Examine other drawings and specifications and bring to the attention of the Architect prior to bid time any omissions or discrepancies in this Division.

1.02 CODES, RULES, PERMITS, FEES, APPLICABLE PROVISIONS:

- A. The Contractor shall comply with all local, municipal and state laws and the latest revision of the regulations of the National Electric Code, the International Building Code, the International Plumbing Code, the International Gas Code and the International Mechanical Code, in the performance of his work wherever these laws and regulations may apply.
- B. The Contractor shall give all required notices, obtain necessary permits and pay all required fees.
- C. Deliver to Architect, permit and licenses, including certificates from local and state health departments approving complete sanitary and water systems. Furnish certificates from fire department approving fire protection system and equipment.
- D. Before and/or at completion of work, the Engineer shall cause to be made any and all tests which he may consider necessary. Should it develop during tests that the work is defective and does not comply with these specifications, such changes as are necessary shall be made to put the work in proper condition and the expense of such subsequent tests shall be borne by this Contractor.
- E. The following requirements are supplementary to the tests specified for individual equipment and/or systems in this section of these specifications:

1. Concealed or insulated work shall remain uncovered until required tests have been completed, but in the event that the project construction requires it, the Contractor shall make arrangements for tests on portions of the work involved as the project progresses.
2. The Architect shall be notified in advance of all tests and shall be represented at such tests. The cost of labor, material, instruments, etc., required for tests shall be borne by the Contractor, except where specified elsewhere.
3. Acceptance tests for operation and performance as specified and/or required for all equipment and systems shall be in the presence of the Architect, a representative of the Owner, as well as representatives of agencies having jurisdiction, upon completion of the work.

1.03 DRAWINGS:

- A. Project Drawings: The Drawings accompanying this specification are generally diagrammatic and do not show all details of bolts, nuts, connections and the like, required for the complete system and do not indicate the exact location of piping, fixtures, equipment, etc., unless definitely dimensioned or noted. While these drawings shall be followed as closely as possible, all dimensions shall be checked at the building and any necessary changes shall be made in accord with structural and architectural conditions, equipment to be installed or with the work of the different trades, without any additional cost to the Owner and as directed by the Architect. The drawings and specifications are complimentary to the other and what is called for by one shall be as binding as if called for by both. Any component item under this contract shall be furnished and installed by the Contractor without extra charge.

1.04 EXAMINATION OF CONDITIONS:

- A. It is understood and agreed that the Contractor has, by careful examination, satisfied as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the general and local conditions and all other matters which can affect the work under this contract.

1.05 COORDINATION/COORDINATION DRAWINGS:

- A. Coordinate work with other trades to avoid interference and establish necessary space requirements and tie-ins for each trade.
- B. Prior to starting installation, furnish to the General Contractor and all Subcontractors concerned, copies of approved shop drawings showing location of equipment, piping, etc.
- C. Schedule periodic meetings with other trades before and during installation to avoid conflicts and assure that pipes and equipment are installed in the best manner, taking into consideration head-room, maintenance, appearance and replacement.
- D. The mechanical contractor shall produce either AutoCAD or Revit coordination drawings including the mechanical, electrical, plumbing, and fire sprinkler systems to be installed in order to avoid installation conflicts during construction. Coordination meetings shall be held after completion of these drawings to resolve potential installation conflicts. Additionally, a 3-dimensional drawing of the proposed mechanical room piping and equipment layout shall be generated and submitted to

the engineer for approval prior to any pipe or equipment installation in the main mechanical room. This drawing shall include all equipment to be installed in this space. Any mechanical equipment, ductwork, or associated appurtenance that is installed prior to receiving written coordination drawing approval from the engineer is subject to removal and replacement of all installed material at the contractor's expense. This relates to coordination and installation deficiencies with respect to the requirements of the contract documents as identified by the engineer, architect or the commissioning agent.

END OF SECTION 15010

SECTION 15040 – GENERAL COMPLETION

PART ONE – GENERAL:

1.01 GENERAL REQUIREMENTS FOR INSTALLATION:

- A. Piping, fixtures, equipment, etc. shall be located to avoid interference with structural and architectural conditions or with the work of different trades. Provide off-sets where necessary to avoid footings, piers, columns, beams, windows, piping, electrical fixtures and other systems, etc. Specifically inform the General Contractor as to the correct size and location of all chases, openings, supports, sleeves, etc. required for the system. Furnish and install sleeves, inserts, bolts, etc. and all arrange for the cutting of walls, floors, roofs, etc. and the proper closing of all openings. Cutting of construction, where unavoidable, must be done by the General Contractor but shall be paid for by this Contractor. No part of the building may be broken out, cut, burned or permanently removed without the approval of the Architect.

PART TWO – PRODUCTS:

2.01 WORKMANSHIP AND MATERIALS:

- A. Workmanship shall be of the best quality and none but competent mechanics skilled in their trades shall be employed. The Contractor shall furnish the services of an experienced superintendent who will be constantly in charge of the erection of the work until completed and accepted.
- B. Unless otherwise hereinafter specified, all materials and equipment shall be new, of best grade and as listed in printed catalogs of the manufacturer. Each article of its kind shall be the standard products of a single manufacturer.
- C. The Architect shall have the right to accept or reject material, equipment and/or workmanship and determine when the Contractor has complied with the requirements herein specified. Where departures from indicated arrangements are required, written approval for such changes shall be obtained from Architect's representative.
- D. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.
- E. All material and equipment used on this project shall be stored in a weatherproof bonded warehouse. Contractor shall submit insurance certificate to the Architect prior to storing any materials or equipment. No equipment, materials or roof-top heat pumps used on this project shall be stored outside exposed to the weather. Before final payment can be made, a notarized statement with the material invoiced to the Owner must be furnished to the Architect.

2.02 DIVISION OF WORK:

- A. Coordinate all opening locations with General Contractor, see paragraph 2.04.
- B. This Contractor shall furnish roof curbs and caps. Curbs and caps to be installed and flashed by the General Contractor, unless otherwise noted.
- C. Furnish door grilles to General Contractor for installation.
- D. Refer to the Electrical and Control Sections of this specification. The Electrical Subcontractor shall provide all wiring except:
 - 1. Temperature Control Wiring
 - 2. Equipment Control Wiring
 - 3. Interlock Wiring

The Electrical Subcontractor shall furnish all power wiring complete from power source to motor or equipment junction box, including power wiring through starters. Electrical Subcontractor shall install all starters not factory mounted on equipment. The Mechanical Subcontractor shall, regardless of voltage, provide all temperature control wiring for equipment provided under this Division. The Mechanical Subcontractor shall furnish all starters and contactors to the Electrical Subcontractor and shall provide and be responsible for over-load heaters in all starters furnished. Over-loads shall be provided in each ungrounded conductor.

2.03 FINISHES:

- A. Finishes for all water coolers, grilles, registers, diffusers, room fan coil units, room air conditioning units, louvers and any other item exposed to view shall be selected by Architect and shall be equivalent to baked enamel. Submit color charts along with submittal data.

2.04 OPENINGS – CUTTING, REPAIRING:

- A. This Contractor shall cooperate with the work to be done under the other sections in providing information as to openings required in walls, slabs and footings for all piping and equipment, including sleeves, where required.
- B. All drilling, cutting and patching required for the performance of work under this Section shall be performed by the General Contractor and the cost thereof shall be borne by this Contractor.
- C. Holes in Concrete: Sleeves shall be furnished, accurately located and installed in for before pouring of concrete. This Contractor shall pay all additional costs for cutting of holes as the result of the incorrect location of sleeves. All holes through existing concrete shall be either core drilled or saw cut. All holes required shall have the approval of the Structural Engineer prior to cutting or drilling. All penetrations shall be grouted all around with cement.

2.05 EXCAVATION AND BACKFILL:

- A. General: The Contractor shall do all excavating and backfilling necessary to receive the work shown on the drawings.

Excavations shall be made to the proper depth and the trenches shall be graded uniformly to provide a solid bearing along the entire length of the pipe. Bell holes shall be provided in trenches at the joints in hub and spigot pipe to facilitate caulking and so that piping will not be supported in hubs. All trenches shall be excavated so that pipes will have at least six (6) inches clearance on each side. Pipes in fill or loose sand shall have trench bottom tamped to 95% maximum density compaction prior to laying pipe.

- B. Dewatering and Shoring: Pumps shall be furnished as required to keep trenches dry during the laying and jointing of the mains. Provide shoring where required, maintaining trenches against settlement until final acceptance.
- C. Backfilling: Do not fill any trenches until all piping has been inspected. After the work is installed, tested, inspected and approved, the trenches shall be refilled in six (6) inch layers with clean, damp earth, with each layer thoroughly tamped before proceeding with additional layers. Remove from site all excess earth, rock and other debris resulting from excavation and backfill work.

2.06 NAMEPLATES:

- A. On all manufactured equipment, provide engraved plastic nameplates as manufactured by Seton Nameplate Co., Columbia-Engravers, International Nameplate Co. or equal. Unless otherwise noted, nameplates shall be 1/16" thick plastic with white letters on a black background. Attach nameplates with two (2) round-head chrome plated screws.
- B. Unless otherwise noted, letters identifying equipment in equipment rooms to be 1/2" high. All other letters shall be 1/8" high. Hand lettering, under typing tape, embossed letters on plastic, etc. will not be acceptable.
- C. Provide additional nameplates for mechanical equipment that is suspended above lay in/accessible ceilings. Nameplates shall be located directly below suspended equipment and attached to the ceiling gird (not tiles) to indicate approximate location of equipment.

2.07 CLEANING EQUIPMENT AND MATERIALS:

- A. Provide for the safety and good condition of all materials and equipment until final acceptance by the Owner. Protect all materials and equipment from damage. Provide adequate and proper storage facilities during the progress of the work. Special care shall be taken to provide for bearings, open connections, pipe coils, pumps and similar equipment.

- B. All fixtures, piping, finished surfaces and equipment shall have all grease, adhesive labels and foreign materials removed.
- C. All piping shall be drained and flushed to remove grease and foreign matter. Pressure regulating assemblies, traps, flush valves and similar items shall be thoroughly cleaned. Remove and thoroughly clean and reinstall all strainer screens after the system has been in operation for ten (10) days.

2.08 CLEANING UP:

- A. Remove from the premises all unused material and debris resulting from the performance of work under this section.

2.09 DAMAGES:

- A. Cost of repairing damage to building, building contents and site during the construction and guarantee period resulting from this work including damage to ceilings or walls is a part of this contract.

2.10 FINISHED PLANS:

- A. As-Build Drawings: Upon completion of work, the Contractor shall furnish and deliver to the Owner two (2) sets of as-built drawings to correspond in size to the tracings, showing among other things, layouts of utility systems and functional systems (such as air distribution, water, storm drainage and sanitary sewer). All pertinent dimensions and elevations of buried work shall be given.

2.11 INSTRUCTIONS:

- A. Provide a hard-back, three-ring file folder containing all warranties, catalog data and the manufacturer's recommendations and the frequency with which each is to be done. Each sheet shall be initialed by the manufacturer's agent as being correct. Provide columns on each sheet so that they may be dated by maintenance personnel when each individual function is performed. Contractor shall furnish a typed maintenance manual in hard-back, three-ring binder explaining all maintenance functions. The Contractor shall instruct and demonstrate each maintenance function to the Owner's Representative. The Owner's Representative shall in turn, sign the maintenance sheets indicating his/her understanding of the instructions. Coordinate all equipment start-ups with the Owner so that they may be present.
- B. The Contractor shall instruct the Owner's Representative in complete detail as to the proper operation of the overall system. Advise the Owner as to where to order common replacement items. Deliver to the Owner, the manufacturer's agent's name, address and telephone number of each piece of equipment.
- C. The Contractor shall provide a complete listing of filter sizes and counts of all mechanical equipment to Owner's Representative.

2.12 GUARANTEE:

The Contractor agrees:

- A. Contractor shall correct defects in workmanship materials, controls and operation of the system for a period of 1 year from the date of substantial completion and acceptance of work. Any equipment/material installed by the contractor replaced during the first-year warranty period shall be guaranteed for an additional year starting from the date of replacement. A manufacturer 5-year parts and labor warranty shall be provided for all HVAC equipment that utilizes a compressor or compressors. This warranty shall cover the entire refrigeration system including the refrigerant. The manufacturer's warranty certificate shall be included in the contractor's closeout documents provided at the completion of the project.
- B. That the systems installed will safely, quietly and efficiently perform their respective functions in accordance with the design.
- C. To service completely the systems for a period of one (1) year.

This work shall include: Adjustment of belts and drives, care of cooling towers (where applicable), complete oiling and greasing of mechanical equipment and labor for changing of air filters. Replacement filters will be furnished by the Owner. Contractor is responsible for providing and changing filters with the frequency as deemed necessary by the engineer and/or commissioning agent during the building construction. All HVAC units that are operated during construction shall have MERV 8 Minimum construction filters. Final Operating filters shall be MERV 8 minimum. Additionally, contractor shall protect all ductwork and mechanical equipment openings with construction quality sheet plastic to prevent construction dust/debris from entering into air or water moving equipment. All equipment, pipe, ductwork or related appurtenances fouled by construction debris shall be removed and replaced. Ventilation air units shall not be used to dehumidify the building during construction activities. VAU's shall only be operated after final cleaning of the building.

END OF SECTION 15040

SECTION 15050 – BASIC MATERIALS AND METHODS

PART ONE – GENERAL:

1.01 APPROVALS AND SUBSTITUTIONS:

- A. All requests for substitutions shall be submitted so as to be received by the Engineer at least ten (10) days before bid date and must be approved before award of contract.
- B. Contract prices shall be based on material and equipment as specified, unless written approval is obtained for any deviations. Requests for substitutions before bid date may be submitted by Contractors or by Equipment Manufacturer's Representatives.
- C. Requests for approvals shall be submitted in the form of a letter (with one [1] copy minimum) on a letterhead of submitting firm, along with a self-addressed stamped return envelope. Letter shall be addressed to the Engineer and referenced to this project. Faxed requests are not acceptable.
- D. If there are no deviations between the items submitted and the plans and specifications then the submittal letter should contain the statement, "Items are in accordance with plans and specifications with no deviations." An item with deviations from the plans and specifications may be submitted for approval consideration. Letter should then state, "Item submitted is in accordance with plans and specifications, except for the following deviations." Deviations should then be listed in itemized form.
- E. Items approved shall not be construed as authorizing deviations from the plans and specifications. Contractor shall be responsible for verifying all dimensions with available space conditions with provisions for proper access, maintenance and part replacement and for coordination with other trades – electrical, plumbing, structural, etc. for proper services and construction requirements.
- F. Where such approved deviations require a different quality and arrangement of ductwork, piping, wiring, conduit and equipment from that specified of indicated on the drawings, the Subcontractor shall furnish and install any such ductwork, piping, structural supports, insulation, controllers, motors, starters, electrical wiring and conduit and any other additional equipment required by the system at no additional cost to the Owner.

PART TWO – PRODUCTS AND EXECUTION:

2.01 MANUFACTURER'S INSTRUCTIONS:

- A. Prior to purchasing equipment, procure product manufacturer's application, installation and operating instructions for use in conjunction with the system design drawings and specifications during construction. If there is any conflict between the manufacturer's publications and the design drawings and specifications, immediately notify the Engineer in writing. Upon notification by the Engineer, proceed in accordance with his/her instructions.

2.02 SHOP DRAWINGS:

- A. The Subcontractor shall submit for approval detailed shop drawings of all equipment and all material required to complete the project and no material or equipment may be delivered to the job site or installed until the Subcontractor has in his possession the approved shop drawings for the particular material or equipment. The shop drawings shall be complete as described herein. The Subcontractor shall furnish the number of copies required by the General Contractor and Special Conditions of the contract but in no case less than six (6) copies. Shop drawings shall be submitted in appropriately sized 3-ring binders. Submittals shall be comprehensive and include all equipment/products to be provided. Partial submittals will be disapproved.
- B. Prior to delivery of any material to the job site and sufficiently in advance of requirements to allow Architect ample time for checking, submit for approval detailed dimensional drawings or cuts showing construction, size, arrangement, operating clearances, performance characteristics and capacity. Each item of equipment proposed shall be a standard catalog product of an established manufacturer and of equal quality, finish and durability to that specified.
- C. Samples, drawings, specifications and/or catalogs submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, Contractor's name and name of project.
- D. Catalogs, pamphlets or other documents submitted to describe items on which approval is being requested shall be specific and identification in catalog, pamphlet, etc. of each item submitted shall be clearly made in ink. Data of a general nature will not be accepted.
- E. Approval by the Architect and/or Engineer of shop drawings for any material, apparatus, devices and layouts shall not relieve this Contractor from the responsibility of furnishing same of proper dimension, size, quantity, quality and all performance characteristics to efficiently perform the requirements and intent of the contract documents.

In addition, approval shall not relieve this Contractor from responsibility for errors of any sort on the shop drawings. If the shop drawings deviate from the contract documents, this Contractor shall advise the Architect and/or Engineer of the deviations in writing accompanying the shop drawings, including the reasons for deviations.

- F. Failure of the Subcontractor to submit shop drawings in ample time for checking shall not entitle him/her to an extension on contract time and no claim for extension by reason of such default will be allowed.

END OF SECTION 15050

SECTION 15700

PACKAGED HEAT PUMPS

PART ONE – GENERAL:

- 1.01 Unit shall be self-contained, roof mounted type consisting of filters, evaporators, fan and motor, electric heaters, outside air intake, cooling coil, condensate collector and drain, compressor, condenser fan and motor, inter-connecting refrigerant piping and factory installed controls with 24V remote control center. The units shall be designed in accordance with UL requirements, A.R.I. rated and meet all applicable requirements of ASHRAE 90.1.
- 1.02 Units shall be as manufactured by Trane.

PART TWO – PRODUCTS:

2.01 UNIT CASING:

- A. Cabinet: Galvanized steel phosphatized and finished with an air-dry paint coating with removable access panels. Structural members shall be 16 gauge with access doors and removable panels of minimum 20 gauge.
- B. Units' cabinet surface shall be tested 500 hours in salt spray test in compliance with ASTM B117.

2.02 AIR FILTERS:

- A. 2" pleated media filters shall mount integrally within the unit and shall be accessible through access panels.

2.03 MOTOR COMPRESSORS:

- A. Motor compressors shall be manufacturer's standard spring mounted hermetic type fully serviceable on job location with five (5) year warranty.

2.04 FANS:

- A. Fans shall be forward double width double inlet centrifugal type fan with self-aligning grease lubricated ball or sleeve bearings with permanent lubrication fittings. Fans shall have internal thermal overload protection.

2.05 ELECTRIC HEATERS:

- A. Electric heaters shall be of the open coil type designed to fit within the unit. Heaters shall be complete with contactors, control transformer, automatic

thermal high limit, manual reset high limit control, fan interlock, fuse block with fuse for each phase and disconnect. Heaters must be UL listed.

2.06 COILS:

- A. Provide a thermal expansion valve for each refrigeration circuit. Factory pressure test at 450 psig and leak tested at 200 psig. Coils shall be configured with aluminum fin surface mechanically bonded to copper tubing coil.

2.07 REFRIGERATION SYSTEM:

- A. Compressor(s): Provide compressors with direct drive operating at 3,600 rpm integral centrifugal oil pump, inlet dir separator, rolling element bearings, crankcase heater, completely enclosed compression chamber with no leakage paths. Provide suction cooled motor with over-temperature and over-current protection.
- B. Compressor(s) shall be manufactured by the HVAC unit manufacturer.
- C. Units shall have cooling capabilities down to 60 degrees F.
- D. Provide with thermostatic temperature control in the compressor windings to protect against excessive temperatures-, high- and low-pressure conditions.

2.08 CONTROLS:

- A. Units shall have factory wired controls including all components necessary for standard sequences of heating and cooling.

2.09 ACCESSORIES:

- A. Unit shall come with factory outside air intake hood with bird screen and balancing and motorized dampers. Coordinate with Controls Specifications as applicable.
- B. Provide factory coil guards for condenser coils.
- C. Provide with energy recovery ventilation package and hot gas reheat where indicated on plans.

2.10 WARRANTY:

- A. Heat pumps shall be provided with a warranty of two (2) years for parts and labor plus an additional three (3) years parts and labor on the compressors.

PART THREE – EXECUTION:

- 3.01 Mount unit on structural aluminum or hot dipped galvanized seismic roof curb per Section 23 05 48 with flashing assembly that complies with the National

Roofing Contractors Association requirements. The roof curb on the top elevation must be true and level. Contractor shall provide supplemental steel to attach curb to structure as recommended by seismic curb manufacturer. See Seismic Specifications for product and design criteria.

- 3.02 Provide 1" Type "L"- hard copper P-trap assembly at each condensate drain connection with threaded cleanout plug. Depth of trap shall be sufficient for drainage with static pressure of unit.

END OF SECTION

SECTION 15750

SPLIT SYSTEM VAV UNITS

PART ONE – GENERAL:

- 1.01 Unit shall be provided with mixing section consisting of filters, evaporators, fan and motor, outside air intake, cooling coil, condensate collector and drain compressor, remote condenser, condenser fan and motor, field installed inter-connecting refrigerant piping and factory installed controls with 24V remote control center. The units shall be designed in accordance with UL requirements, be A.R.I. rated and meet all applicable requirements of ASHRAE 90.1.
- 1.02 Units shall be as manufactured by Trane.

PART TWO – PRODUCTS:

2.01 CASING:

- A. Casing shall be pre-insulated double wall galvanized steel with ASTM B117 finish.

2.02 COILS:

- A. Coils shall be manufacturer's standard copper tubing and aluminum fins of sufficient size to provide the cooling requirements as scheduled on the drawings.

2.03 MOTOR COMPRESSORS:

- A. Motor compressors shall be 4 stage minimum scroll type fully serviceable on job location.

2.04 FANS:

- A. Evaporator fans shall be of centrifugal double inlet forward curve blade type. Fans shall be statically and dynamically balanced and shall be run on permanently lubricated bearings. Fan shall have variable frequency drive. Provide optional three (3) contactor key operated drive-off-bypass selector switch to bypass drive in the event of drive failure.

2.05 FILTER SECTION:

- A. Provide 2" throw away type filters with 90% arrestance rated in accordance with ASHRAE 52-76.

2.06 CONTROLS:

- A. Unit shall be controlled by the BAS system as manufactured by Siemens. Coordinate factory installation of controllers with Control Management, Inc.

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2.07 ACCESSORIES:

- A. Unit shall be provided with factory outside air intake TRAQ dampers with balancing and motorized dampers and airflow station. Coordinate with Controls Specifications as applicable.
- B. Provide factory coil guards and seacoast coating for condenser coils.
- C. Unit shall be provided with hot gas reheat with minimum capacity as scheduled to produce neutral air.
- D. Provide field installed duct mounted electric heat with unfused single point power connection disconnect and SCR control. Duct heater shall be as specified by Warren Technology model CBK.

PART THREE – EXECUTION:

- 3.01 Contractor shall install all refrigerant piping, hot gas bypass, hot gas reheat refrigerant circuit, filter/dryers, and accessories on strict accordance with manufacturers piping diagrams. Refrigerant piping shall be sized by the equipment manufacturer and shall be inspected by factory personnel prior to factory startup for compliance with manufacturer's literature. Provide installation compliance checklist to engineer for reference with closeout documents.
- 3.02 Provide 1" Type "L" hard copper P-trap assembly at each condensate drain connection with threaded cleanout plug. Depth of trap shall be sufficient for drainage with static pressure of unit.
- 3.03 Refrigerant and condensate piping shall be insulated with ¾" Armaflex elastomeric insulation with glued and taped joints. Additionally, all exterior refrigerant piping shall be covered with 28 GA. 304 stainless steel jacketing and secured with stainless steel bands at 2' O.C.
- 3.04 System shall be provided with a factory warranty of five years for parts and labor for the entire unit.

END OF SECTION

SECTION 15808 – DUCTWORK

PART ONE – GENERAL:

- 1.01 Ductwork, including exhaust, shall conform to all applicable requirements of the latest issue of NFPA Pamphlet No. 90A. All ductwork, elbows, take-offs, transitions and etc. shall conform to the recommendations of SMACNA duct construction standards as a minimum requirement, unless otherwise indicated by the contract documents.
- 1.02 Ductwork shall be installed to operate without noise or vibration and shall be air tight. The Contractor shall be responsible for measuring at the building all conditions, space available, piping, light fixtures, ceiling heights, etc. that affect ductwork installation prior to fabrication. Ductwork shall be constructed as job progresses, not in advance.

PART TWO – PRODUCTS:

2.01 **LOW PRESSURE DUCTWORK:**

- A. Low pressure and exhaust ductwork shall be galvanized sheet steel constructed to the requirement of SMACNA Table 1-5 for 2" W.G. static pressure, unless otherwise noted. Duct and fitting sealing requirements shall be in accordance with SMACNA Table 1-2, Seal Class "A". Duct tape is not allowed. Seismic restraints shall be provided for all ducts with a cross sectional area of six (6) square feet and larger in accordance with the International Building Code, International Mechanical Code and SMACNA Seismic Restraint Manual, Latest Edition. Gauges and reinforcing shall be as follows:

MAXIMUM SIDE INCHES	STEEL U.S. STANDARD GAUGE*	TYPE OF TRANSVERSE JOINT CONNECTIONS	BRACING
Up to 24	24	S, Drive, Pocket or Bar Slips, 7'-10" o.c.	None
25 to 30	24	S, Drive, Pocket or 1" Bar Slips, 7' – 10" o.c.	1" x 1" x 1/8" Angles 4' o.c.
31 to 40	22	Drive, 1" Pocket or 1" Bar Slips on Centers	1" x 1" x 1/8" Angles 4' o.c.
41 to 60	22	1 1/2" Angle Connections, 1 1/2" Pocket or 1 1/2" Bar Slips with 1 3/8" x 1/8" Bar reinforcing 7' 10" o.c.	1 1/2" x 1 1/2" x 1/8" Angles 4' o.c.

61 to 90	20	1 1/2" Angle Connections, 1 1/2" Pocket or 1 1/2" Bar Slips with 1 3/8" x 1/8" Bar reinforcing 7'10" o.c.	1 1/2" x 1 1/2" x 1/8" Angles 2' o.c.
91 and Up	18	2" Angle Connections, 1 1/2" Pocket or 1 1/2" Bar Slips with 1 3/8" x 1/8" Bar reinforcing 3'9" o.c.	1 1/2" x 1 1/2" x 1/8" Angles 2' o.c.

2.02 ROUND INSULATED FLEXIBLE DUCTS & SPIN-IN COLLARS:

- A. Insulated flexible ducts shall consist of an inner core of acoustically transparent CPE inner film or perforated corrugated aluminum with sound attenuating features complete with a factory applied exterior jacket of R 4.5 fiberglass insulation and reinforced metalized vapor barrier with 0.05 ASTM E96 permeance rating. Duct shall be UL listed as Class 1 air duct, standard UL 181 with flame spread and smoke developed ratings of 25 and 50 respectively.
Minimum working pressure shall be 4" W.G. positive. Flexible ducts shall be:
- (1) Flexmaster 1M – Acoustical Insulated
 - (2) Clevaform – Clevaform DB-series-type DBA acoustical duct
- B. Spin-in collars shall be constructed of galvanized steel with scoop and damper.

PART THREE – EXECUTION:

- 3.01 *Gauge Stamps: Turned out and on bottom of ducts.
- 3.02 All supply and return duct elbows with an inside radius of less than 3/4 of duct width shall have single thickness turning vanes. All square elbows shall have double thickness turning vanes.
- 3.03 All exhaust duct elbows shall have not less than 6" inside radius. All square elbows shall have single thickness turning vanes.
- 3.04 Splitter dampers and branch take-off extractors shall be installed where indicated and shall be adjustable and shall have locking quadrants.
- 3.05 All branch take-offs shall be 45-degree entry type per SMACNA Fig. 2-6. No straight tap or butt fittings allowed.
- 3.06 Flexible duct connections shall be provided where ductwork connects to equipment and shall be Ventglas 30 oz. woven glass fabric double coated with neoprene, fire retardant, waterproof, air tight and UL listed.
- 3.07 Duct sizes indicated on plans are interior dimensions. Increase metal duct sizes as required for acoustical or interior insulation.
- 3.08 All ductwork shall be supported by 1" x 1/8" galvanized iron straps with a maximum spacing of 8'. Straps shall be bolted or clamped to the structure and be turned and fastened to bottom of the duct so that duct weight is not on the fastening screws.

- 3.09 Provide 1" diameter test slots with cover for insertion of thermostat or test instruments at all locations required to perform operations under paragraph "Balancing."
- 3.10 Provide duct access doors to afford easy access to entering air side of items requiring maintenance or inspection (such as thermostats, fire damper, etc.). Doors shall be of ample size for service required (18" x 12" minimum) and provided with frame, brass hinges, handle, clamping device and gasket for air tight joint.
- 3.11 Round flexible ducts shall be installed in extended condition free of sags and kinks using only the minimum length required to make the connection. Abrupt bends and turns that crimp the duct and restrict the air flow will not be permitted. Horizontal supports shall be ¾" wide 22-gauge flat galvanized steel sheet banding material. Flexible ducts shall be supported on 36" centers. Maximum allowable length of a flexible duct shall be 8'. If extended run-out is indicated, round galvanized steel shall be used for run-out length in excess of 8'.
- 3.12 The entire duct system shall be free from rattles. If rattles exist after ductwork has been installed, the labor and materials necessary to eliminate rattles shall be done at the expense of this Contractor.
- 3.13 All return duct connections to air devices shall be rectangular unless otherwise indicated on plans. Use of flexible duct is prohibited on any return or exhaust ductwork.
- 3.14 Where ceiling plenum returns are used, the return duct shall be fitted with a bell-mouth entry covered with 1" x 1" galvanized hardware cloth.
- 3.15 Kitchen hood exhaust ductwork systems shall be constructed to the requirements of NFPA 96. Ductwork shall be a minimum of 18-gauge 316 stainless steel with all seams and joints sealed liquid tight with a continuous external weld. Dishwasher hood exhaust shall be 16-gauge stainless steel.
- 3.16 Prior to substantial completion, Contractor shall retain an independent licensed and professional testing agency that specializes in indoor air quality that will test for excessive dust and/or debris that may be present in the duct system. If it is determined that cleaning of duct is necessary, the Contractor shall employ a qualified duct cleaning agency to perform the work at no additional cost to the Owner.

END OF SECTION 15808

SECTION 15820 – DAMPERS

PART ONE – GENERAL:

- 1.01 Mechanical Contractor shall furnish and install all dampers as indicated on drawings or called for under Specifications.
- 1.02 Dampers shall be as manufactured by Air Balance, Inc., Phillips-Aire, Ruskin Manufacturing Co. or Louvers and Dampers, Inc.

PART TWO – PRODUCTS:

2.01 MANUAL & AUTOMATIC DAMPERS:

- A. Manual and automatic dampers shall be of the multi-louver opposed blade type equipped with an external operating shaft. Locking device shall be provided for manual dampers.

2.02 FIRE DAMPERS:

- A. Fire dampers for low pressure and exhaust ductwork shall be parallel blade positive closure mounted in a galvanized steel channel frame. Dampers shall be curtain type meeting all UL 555 and NFPA requirements. Dampers shall be high free area style with blade package mounted out of air stream. Dampers in stainless steel ductwork shall be constructed of type 304 stainless steel. Fuse line shall be 160 degrees. Fire dampers shall have a UL label with a 1 ½ hour rating for use in partitions with ratings of up to two (2) hours. Fire dampers shall have a UL label with a three (3) hour rating for use in partitions with ratings of up to four (4) hours.
- B. Fire dampers shall be provided as follows:
 - 1. In all duct passages through fire rated assemblies.
 - 2. In all duct passages through floor.
 - 3. In fire rated openings used for return air passages.
 - 4. See Architectural floor plans for locations and ratings of all fire rated assemblies.
- C. Ceiling radiation dampers shall be installed at air device penetrations of a fire rated ceiling. Dampers shall be UL listed with 165 degrees F. fusible link. Phillips-Aire Series 8 (rectangular) or 9 (round) dampers or approved equal.

2.03 SMOKE DAMPERS:

- A. Smoke dampers shall be classified by Underwriters Laboratories as Leakage Rated Dampers for Use in Smoke Control Systems under the latest version of UL Standard 555S and shall bear a UL label. Smoke dampers and their operators shall be qualified under UL 555S to a minimum elevated

temperature of 250 degrees F. Dampers shall be qualified at UL 555S Leakage Class II. Combination dampers shall comply with both UL 555 and UL 555S.

- B. Electric operators shall be installed by the damper manufacturer at time of damper fabrication. Installation of damper with operator and smoke detectors shall be coordinated with Controls Contractor to provide a complete and operational smoke damper in accordance with NFPA 90A.
- C. Provide smoke dampers and smoke detectors at each duct penetration of a smoke wall. Refer to Architectural plan for locations of all smoke walls. Refer to control sections of Specifications for smoke detector hardware requirements. Detectors shall meet requirements of NFPA 72.

PART THREE – EXECUTION:

- 3.01 Fire and smoke dampers shall be provided with access doors to operate and reset. Provide identification markers with lettering a minimum of ½” high on each access door stating “fire damper” or “smoke damper” as applicable per requirements of I.B.C. 715.4 and I.M.C. 607.4. Areas around dampers shall be fire stopped with fire resistant materials consistent with UL tested assembly requirements.
- 3.02 Where fire and smoke dampers are located above a hard or security ceiling, Contractor shall provide access doors in ceiling to reach dampers. Coordinate door and frame style with Architectural Finish Schedule. Submit to Architect for approval.

END OF SECTION 15820

SECTION 15850 - INSULATION

PART ONE - GENERAL:

- 1.01 All insulation shall have a composite fire and smoke hazard rating which shall include insulation, jacket, facing, and adhesive. Flame spread rate shall not exceed 25 with smoke development not in excess of 50. Accessories (adhesives, mastics, cements, tapes) shall be rated as specified for insulation. Samples of all types of insulation shall be submitted for approval. Piping and duct work shall be tested, thoroughly cleaned and approved before insulation is applied.

PART TWO - PRODUCTS:

- 2.01 Insulation shall be as manufactured by Manville, Certain-Teed, Owens-Corning, Knauf, or approved substitute.

PART THREE - EXECUTION:

3.01 SUPPLY, RETURN, AND OUTSIDE AIR DUCTWORK:

- A. All concealed ductwork, including flexible duct connections, diffuser boots, and backs, VAV box heater/manifold sections, etc. shall be insulated with 2" thick, 1 pcF density, flexible insulation with factory applied vapor barrier consisting of Foil-Scrim-Kraft. Insulation shall be secured to ductwork with Benjamin Foster 85-20 adhesive. All joints shall be stapled and finished with a 3" wide strip of glass fabric and mastic.
- B. All exposed ductwork shall be insulated internally with 1" Armaflex type SA insulation secured with weld pins. Ductwork in mechanical rooms is considered concealed.
- C. All transfer air ducts shall be insulated internally as described for exposed ductwork above.

3.02 DUCTWORK SERVING VENTILATION AIR UNITS:

- A. All supply and return/exhaust air ductwork serving ventilation air units shall be externally insulated with 2" Armaflex type SA sheet elastomeric insulation secured with weld pins. Exterior ductwork shall be covered with 26 GA stainless steel jacketing and flashed to the exterior wall of the building weathertight.

END OF SECTION 15850

SECTION 15890 - VIBRATION AND SEISMIC CONTROL

PART ONE - GENERAL:

- 1.01 All vibration isolation and seismic control materials specified herein shall be provided by a single manufacturer to assure single responsibility for their proper performance. Installation of all vibration and seismic control materials specified herein shall be accomplished following the manufacturer's written instructions.
- 1.02 The Contractor shall furnish a complete set of shop drawings and other necessary information, of all mechanical equipment to receive vibration isolation and seismic devices, to the vibration isolation and seismic control materials manufacturer. The information to be furnished shall include operating weight of the equipment to be isolated, distribution of weight to support points and dynamic characteristics along with any internal isolation systems to be analyzed. The Contractor shall also furnish a complete layout of piping and ductwork to be isolated, including vertical risers, showing size or weight and support points of the piping and ductwork system, to the vibration isolation and seismic control materials manufacturer, for selection and layout of mountings.
- 1.03 The vibration and seismic control materials manufacturer shall use the above listed information to design a complete system of vibration and seismic mounts in accordance with the contract documents along with the International Building Code with date as indicated on the code analysis section of the contract documents, SMACNA "Seismic Restraint Manual" latest edition, and ASHRAE HVAC Applications handbook, Sound and Vibration Control section, latest edition. The vibration and seismic control materials Contractor shall analyze all "multiple degrees of freedom" systems and provide properly designed isolation systems avoiding all resonance frequencies. To accomplish this, the vibration and seismic control materials supplier shall employ an Engineer registered in the State of South Carolina to design all isolation and restraint systems and prepare a complete set of calculations and shop drawing submittals with his professional Engineer's seal certifying that the design meets all requirements of these contract documents. A seismic design "errors and omissions" insurance certificate must accompany submittals from the vibration and seismic Engineer. Manufacturer's product liability insurance certificates are not acceptable.
- 1.04 The vibration and seismic control Engineer or his designated representative shall inspect the project upon completion of the applicable work and provide written certification that the installation is in compliance with the approved shop drawing submittals. This certification shall also bear the professional Engineer's seal and shall become part of the contract closeout documents. All seals shall be signed and dated appropriately.
- 1.05 Vibration and seismic control systems shall be provided by Vibration Mounting and Controls, Mason Industries, Consolidated Kinetics, or prior approved equal.

PART TWO - PRODUCTS AND EXECUTION:

2.01 VIBRATION ISOLATION:

- A. All mechanical equipment shall receive external vibration isolation. Internal component isolation of equipment shall not be considered equivalent but shall be considered when analyzing systems with multiple degrees of freedom.
- B. Vibration isolators shall be selected based upon known operating weight distributions and dynamic characteristics of the isolated equipment, with the quantity and location as required by the component drawing. Isolator type shall be tabulated for each isolated piece of equipment. Complete calculations of vibration analysis shall be included with submittals, including but not limited to fundamental and harmonic frequencies.
- C. Isolators shall have either known non-deflected heights of spring element or calibration markings so that, after adjustment, when carrying their load, the deflection under load can be verified to determine if the load is within the proper range of the isolator and if the correct degree of vibration isolation is being provided.
- D. Isolators shall function in the linear portion of the load versus deflection curve. Theoretical vertical natural frequency shall not differ from the design objectives by more than + 10%.
- E. Spring mounts shall have seismic housings as required by Paragraph 2.02.
- F. Isolation of equipment shall be as follows:
 - 1. Suspended equipment shall be isolated from the building structure by means of noise and vibration isolators. Units shall be supported with spring and neoprene type isolators, springs to be as described above. Isolators shall be VMC Series RSH.
 - 2. Roof mounted equipment shall be isolated from the building structure by means of a structural aluminum or hot dipped galvanized structural steel isolation curb. The structural spring isolation curbs shall bear directly on the roof support structure and be flashed and waterproofed into the roof's membrane waterproofing system. Roof curbs shall be installed to accommodate the pitch of roof. Contractor shall provide and install all supplemental steel required for seismic attachment of curb to structure as designed by manufacturer. Field fabricated curbs shall not be used. Curb shall come factory assembled. No bolt together corners will be allowed. The curb shall consist of a rigid lower section containing properly spaced pockets with fully adjustable spring isolators. All springs shall be color coded for proper identification and spring pocket shall allow for easy removal or replacement of any spring without disturbance of the

supported equipment. Pockets shall have removable waterproof covers to allow for spring adjustment. Spring pockets shall contain combination vertical and horizontal restraint in conjunction with a 1/4-inch-thick neoprene rubber bushing which will resist wind and seismic forces. All springs shall be installed in series with a 1/4-inch-thick neoprene acoustical cup or pad. Curbs supplied shall be factory acoustically lined with 1 inch 3 PCF duct liner. An air tight neoprene seal shall be incorporated into the curb design to prevent air leakage or infiltration. Air seal must not be exposed so that it could be damaged or that in the event of the air seal failure, water could leak into the curb's interior. Wood nailer and flashing shall be provided and curbs shall be manufactured to NRCA standards. Curbs shall include a means of incorporating a sound barrier package, consisting of two layers of waterproof gypsum board furnished and installed by the Mechanical Contractor. Provide 6", R-19 sound attenuating batt insulation equal to Certa Sound as manufactured by Certainteed, batt insulation shall fill all voids within the curb between the roof deck and the unit above. Additionally, the mechanical contractor shall provide 1/2" treated plywood around the entire perimeter of the curb over the rigid insulation supplied by the roofer to allow for roofer to properly flash curb. Individual pier supported curbs are not acceptable. Roof equipment supports to be VMC type P or R.

3. Mechanical equipment as noted shall be mounted on a rigid structural steel base. The equipment including the base shall be mounted on or suspended from vibration isolators as applicable. Base shall be VMC Type WFB.
4. Floor mounted equipment as noted shall be provided with a noise and vibration isolated structural steel concrete slab inertia base mounted on isolators. Spring mounts shall be recessed at corners. Inertia base shall be VMC Type MPF or WPF as applicable.

2.02 SEISMIC CONTROL:

- A. All mechanical equipment, piping, ductwork, etc. shall be provided with seismic restraints in accordance with the International Building Code, International Mechanical Code, and SMACNA Seismic Restraint Manual, Latest Edition requirements, as a minimum.
 1. All equipment isolated or not, shall be bolted to the structure to allow for seismic acceleration with no failure or displacement. All connections shall be positive bolted type; no friction clamps of any kind are allowed.
 2. Provide cable and connection sets for suspended equipment at each of four corners secured to the building structure.
 3. Provide seismic roof curb systems fastened to roof structure for roof top equipment.
 4. Floor mounted equipment shall be provided with seismically housed springs or springs with seismic snubbers as determined by the equipment to be isolated.

END OF SECTION 15890

SECTION 15900 - CONTROLS

PART ONE - GENERAL:

- 1.01 The control equipment shall be the standard product of a single, reputable control manufacturer and shall be installed by trained mechanics regularly employed by the control manufacturer. The system shall be the electric type. A typewritten control sequence shall be framed and displayed where directed.
- 1.02 All items of equipment, materials, and labor necessary and/or incidental to the hereinafter specified sequence of operation shall be provided with the control system. Items such as auxiliary controls, interlocks, relays or other sequencing devices shall be fully coordinated with the heating and cooling equipment approved for the installation.
- 1.03 All control wiring required for this installation is included in this contract and shall be color coded. All control wiring shall be in conduit. Conduit, wiring sizes, and type of insulation shall be in accordance with DIVISION 16E - ELECTRICAL, and shall conform to the latest issue of the National Electrical Code. All electrical equipment shall bear UL labels. Each control circuit shall be protected by a circuit breaker of the proper size.

PART TWO - PRODUCTS AND EXECUTION:

- 2.01 SMOKE WALLS:
- A. Contractor shall provide circuits, conduit, wire, detectors, and listed operator/smoke damper at each duct penetration of a smoke wall in accordance with NFPA 72 and 90A.
- 2.02 THERMOSTATS/HUMIDISTATS:
- A. Thermostats shall be mounted 48" above finished floors, unless otherwise noted. Provide heavy-duty key lock steel guards by "AA" Industries, Model T18L secured to wall with lead anchors and #10 screws or equal by Shaw-Perkins.
- 2.03 CONTROLLERS:
- A. All controllers shall be labeled with engraved bakeolite plastic plates indicating control function and correct set point. Label shall clearly relate to controller by functional name as indicated on control wiring diagram.
- 2.04 FIRE PROTECTION:
- A. All air handling units 2000 CFM and above shall be provided with smoke detectors in

the return air ducts and smoke dampers in accordance with the International Mechanical Code. Air handling units that are a part of a smoke control system shall have smoke detectors and smoke dampers regardless of capacity.

- B. The smoke detectors shall be designed to detect combustion gases, fire and smoke in the supply and return air streams of the air handling units as indicated. The smoke detectors shall consist of sampling tubes which extend into the return and supply air section and, while the fan is operating, shall continuously sample air. The smoke detector shall be of the ionization type. Materials and equipment shall be the standard catalogued products of concerns regularly engaged in the manufacture of the products and shall be the latest standard design that conforms to the specification requirements and bear the UL label and Factory Mutual Laboratories label. The smoke detection system shall be interlocked with the smoke dampers and air handling unit fan motor and shall, when energized, close the smoke dampers and shut down the fan motor. Smoke dampers shall be wide open before air handling unit fan motor begins operating. Smoke detectors shall have reset switch and red alarm light. Provide extra contacts for tie-in with building fire alarm system. If no fire alarm system is provided under Division 16, this Contractor shall provide an alarm panel with visual and audible signals for each detector with a location map. Graphic annunciator panel shall be located at a constantly attended location per I.M.C. Section 6.06.4.1. Coordinate location with Owner and Architect. Installation shall meet requirements of NFPA 72.
- C. Smoke Dampers: Dampers shall meet the requirements of NFPA 72, 90A, UL 555 and 555S. All damper frames shall be constructed of No. 13 gauge galvanized sheet metal and shall have hat-shaped end channels for duct mounting. Damper blades shall not exceed 6" in width. All blades are to be corrugated type construction, fabricated from two sheets of No. 22 gauge galvanized sheet-metal spot welded together. All damper blade bearings are to be made of oil impregnated sintered bronze and will turn freely in the frame. Replaceable synthetic elastomer seals shall be provided. The dampers shall be provided with seals installed along the top, bottom and sides of the frame and along the upper edge of each blade edge. Seals shall provide a tight-closing, low-leakage damper. Leakage and flow characteristics charts shall be submitted prior to installation of dampers.
- D. Furnish shop dampers to ductwork contractor for installation. Control contractor shall supervise damper installation.
- E. For air handling units 2000 CFM and under capacity but serving an area used for egress, provide smoke detectors in accordance with International Mechanical Code requirements.
- F. Provide necessary control devices and wiring to shut off kitchen make-up air units upon activation of the kitchen hood fire extinguishing system. Provide controls to shut off hood exhaust fans when exhaust air temperature reaches 350 degrees F. Interlock with building fire alarm system.

- G. Provide ionization type smoke detector in the inlet of each exhaust fan of 15,000 CFM or more. Sampling tubes shall detect combustion gases and/or smoke and stop the fan when detector is activated. Detector unit shall be equipped with reset switch and red alarm light. Provide extra contacts for tie-in with building fire alarm system.

2.05 ENERGY MANAGEMENT SYSTEM (EMS) - (SEE EMS SPEC. SECTION):

- A. Provide control center located as indicated on the HVAC drawings, per Section 159XX of the specifications. The control center shall contain numbered terminals of sufficient quantity to permit the required connections. Provide two 120v power supplies and a water pipe ground wire inside control center.
- B. Provide conduit and install Belden #9967 2-conductor shield cable from panel to main distribution switchboard. Provide current transformers on main bus bars for demand limiting function.

2.06 CERTIFICATION:

- A. Furnish to the Architect/Engineer two copies of certification signed by authorized representative of the control company that:
 - (1) Control system has been checked-out and operates according to drawings and specifications.
 - (2) All controls are guaranteed unconditionally for one year from date of acceptance and will be serviced for this period free of charge.
 - (3) Photostatic copies of as-built wiring diagram and control zones have been framed under glass and posted on job.
 - (4) Maintenance personnel or responsible party has been instructed as to the operation of control system. Keys for guards and control centers have been turned over to Owner.
- B. The control and energy management systems shall be as manufactured by Siemens.

END OF SECTION 15900

SECTION 15904 ENERGY MANAGEMENT SYSTEM (DDC HEAT PUMP)

PART ONE - GENERAL:

1.01 GENERAL:

- A. This specification defines the minimum equipment and performance requirements for a direct digital control building control system.

Acceptable manufacturer is as follows:

- Siemens

1.02 SUBMITTALS/DRAWING:

- A. The Control Contractor shall submit prior to installation a set of installation drawings and control strategies for review by the Consultant and/or Owner's representative. These drawings shall include the physical location of building control system equipment and system architecture. The complete sequence of operation of the control system shall be provided.
- B. Upon completion of the installation and final system adjustment, the Control Contractor shall provide a full set of as-built drawings of the installation and the control strategies. In addition, the Control Contractor shall provide a floppy disk containing the as-built control drawings in AutoCAD format.
- C. Framed control diagrams shall be mounted on the wall inside the appropriate mechanical room.

1.03 GUARANTEE:

- A. The entire control system shall be installed by the control manufacturer and guaranteed free of defects and shall include required servicing and maintenance for a minimum of one (1) year after final acceptance.

PART TWO - PRODUCTS AND EXECUTION:

2.01 CONTROL AND INTERLOCK WIRING:

- A. All electrical work required under this section of specifications shall comply with the latest National Electrical Code. Control system power supply shall be served by a separate breaker and fused in control center for secondary protection.
- B. The mechanical contractor shall furnish and turn over to the electrical contractor, motor starters for mounting and power connections thru starter to motor. Disconnect switches when required shall be furnished by electrical contractor.

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- C. All control wiring shall be run in rigid conduit below grade or, on outdoor installation. Galvanized EMT may be run in dry wall construction, above ceilings, or in equipment rooms where permitted by electrical specifications.
- D. Control wiring shall be color coded #16 TFF of TFFN wire with 600-volt insulation. Run all wiring between terminal points without changing color. Color code of control wiring shall be as indicated on control wiring diagram. Multi-conductor thermostat cable will not be acceptable.

2.02 TRAINING/OWNER'S INSTRUCTION:

- A. The Control System Contractor shall provide two (2) copies of an operator's manual describing all operating and routine maintenance service procedures to be used with the system. The Control Contractor shall instruct the Owner's designated representatives in these procedures during the start-up and test period. The duration of the instruction period shall be no less than eight (8) hours. These instructions are to be conducted during normal working hours. The instructions shall consist of both hands-on and classroom training at the job site.

2.03 SYSTEM ARCHITECTURE:

- A. The building control system shall consist of a network of independent, stand-alone control units (SCU) and terminal equipment controllers (TEC).
- B. The SCU's shall interface to a new color graphic central operator's computer. All graphic software shall be provided to match the existing graphic format.
- C. Under this contract, a graphic display shall be created for each of the following:
 - overall building layout with temperatures displayed
 - heat pump unit
 - VAV units
 - ventilation air units
 - VAV boxes
 - fans
 - water heaters
 - lighting controls

2.04 OPERATOR INTERFACE:

- A. The building control system shall permit full operator communication including: obtaining information about the performance of his system, allowing the operator to change the system operation, and diagnosing system malfunctions. Operator communication shall be through the use of any one of the following operator terminals, each of which shall be supplied under this contract:

- *portable laptop computer
- *printer
- *central operator's computer

- B. The network shall be addressable as a whole and shall not require referencing a particular control unit for the commanding or monitoring of points on the network.

2.05 LAN CONTROLLER UNIT (LCU):

- A. Each control unit shall be capable of full operation either as a completely independent unit or as a part of the building-wide control system.
- B. Control strategies shall be Owner definable at each control unit, and for all control units in the system from any one (1) operator terminal. Each control unit shall provide the ability to support its own operator terminal if so desired.
- C. Each LAN Controller unit shall include its own microcomputer controller and power supply. All memory shall be stored in an eeprom chip so as to never lose memory upon power failure.
- D. The LCU (field panel) shall be furnished with a use programmable language and internal memory of at least 128K RAM for local storage of extended trend data.
- E. The LCU (field panel) shall have built-in diagnostics to display at the operator terminal the amount of available RAM in each LCU (field panel) on the network.
- F. The network shall be able to detect changes in any LCU's (field panel's) and terminal equipment controller's point status, and report this change to all terminals accessing the network.
- G. The operator shall have the capability to override the operation of any LCU (field panel) or terminal equipment controller by command at a terminal connected to any LCU (field panel) on the network. The LCU (field panel) shall accept and execute operator commands to override all terminal equipment controller functions including set points from the LCU (field panel) operator terminal.

2.06 TERMINAL EQUIPMENT CONTROLLERS:

- A. Terminal equipment controllers shall be provided for each piece of equipment as specified. The energy management system shall support specific controllers for the following types of equipment as a minimum:
 - 1. heat pumps
 - 2. ventilation air units
 - 3. vav units
 - 4. vav boxes
 - 5. exhaust fans
 - 6. water heaters
- B. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences.
- C. Each controller performing space temperature control shall be provided with a

matching room temperature sensor. The sensor may be either RTD or thermistor type.

1. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable laptop or similar operator's terminal to control and monitor all hardware and software points associated with the controller.
 2. Each room sensor shall also include the following auxiliary devices:
 - Set point Adjustment Dial
 - Digital Temperature Read-Out
 - Override Switch
 3. The set point adjustment dial shall allow for modification of the temperature by the occupant. Set point adjustment may be locked out, overridden or limited as to time or temperature through software by an authorized operator at the central workstation, LCU, or via the portable programming tool.
 4. The override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, LCU, or via the portable programming tool.
 5. Each heat pump will have a supply air temperature sensor connected to its corresponding TEC.
- E. Each controller shall have connection provisions for a portable laptop or similar operator's terminal. This connection shall be possible at both the controller and at the matching room temperature sensor as previously specified. The terminal may be used for readout of system variables, override control, adjustment of control parameters, air balancing, servicing and troubleshooting. The terminal shall provide the user with the following functionality as a minimum:
- Display system status (heating, cooling, etc.)
 - Display all point values and set points
 - Set and change all set points
 - Set and change heating/cooling dead-bands
 - Set and change PID loop gains
 - Set and change system mode (occupied/unoccupied)
 - Set and change system mode times
 - Override all set points
 - Override all digital and analog outputs
 - Command all digital and analog outputs
 - Select application mode
 - Assign controller address
1. All communication and displays via the portable terminal shall be in full English language with accompanying English and SI (International System of Units) engineering units for all displayed data. Selection between English and SI units

shall be accomplished via a single keystroke on the portable terminal.

2. In addition to local interface capabilities, all functionality as specified above may be performed both from the central operator's workstation and from any LCU on the communications network via the same portable terminal. From a terminal connected to any LCU it shall be possible to issue global commands to groups of controllers. All commands shall be able to be changed globally from any graphic in the system.

2.07 BUILDING CONTROL FUNCTIONS:

- A. The LAN Controller unit shall be capable of performing the following energy management routines as a minimum:

- *time of day scheduling
- *start/stop time optimization
- *duty cycling (temperature compensated)
- *event-initiated programs

- B. The system shall permit the generation of job-specific control strategies that can be activated in any of the following ways:

- *continuously
- *at a particular time-of-day
- *on a pre-defined date
- *when a specific measured or controlled variable reads a selected value or state
- *when a piece of equipment has run for a certain period of time

- C. Upon a loss of commercial power to any control unit, the other units within the network shall not be affected, and the loss of operation of that unit shall be reported at the designated operator's terminal. Upon resumption of commercial power, the control unit shall resume full operation without operator intervention. The unit shall also automatically reset its clock such that proper operation of timed sequences is possible without the need for manual reset of the clock.

2.08 DIAGNOSTICS:

- A. The system shall also allow on-line diagnosis via telephone modem from a remote location (vendor's headquarters or local branch office or other remote site).

2.09 SEQUENCE OF OPERATION:

- A. Heat Pumps:

1. A Terminal Equipment Controller (TEC) shall be provided for each heat pump. The TEC shall enable the heat pump for operation according to its individual occupied/unoccupied schedule. The TEC shall control the heat pump stages of heating and cooling to maintain the space temperature set points.
2. Motorized outside air dampers shall remain closed during all unoccupied times.

Motorized outside air dampers shall remain closed upon the initial startup of the applicable heat pumps. After the room has reached its warm-up or cool-down temperature, the outside air damper shall open. For packaged heat pumps with energy recovery ventilators, ventilators shall operate only during occupied hours.

3. When commanded to change over to the Unoccupied Mode, the terminal equipment controller shall raise the cooling set point and lower the heating set point to an operator determined value.
4. During the Unoccupied Mode, the terminal equipment controller may be reset to the Occupied Mode for an operator determined time period. This reset shall be activated by a signal from a local override switch on the room temperature sensor or by command from the operator's terminal. At the end of the operator determined time period, the terminal equipment controller shall return to the Unoccupied Mode.
5. For packaged heat pumps with hot gas reheat, a separate humidistat shall be provided to control humidity to a predetermined level.

B. Ventilation Air Units:

1. A Terminal Equipment Controller (TEC) shall be provided for each unit. The TEC shall enable the unit for operation according to its individual occupies/unoccupied schedule. The TEC shall control the stages of cooling to maintain the space temperature and humidity set points.
2. Controls Contractor shall provide space humidity transducers as required.
3. During Occupied Mode the ventilation air units shall provide dehumidified air to each classroom as scheduled on the plans. CO2 sensors in each space will control modulating bypass dampers at ventilation air unit. The most demanding sensor will control the amount of outside air taken in relative to re-circulated air. Ventilation air unit shall remain in re-circulation mode until most demanding sensor reaches 1000 ppm.
4. During the Unoccupied Mode, the terminal equipment controller may be reset to the Occupied Mode for an operator determined time period. This reset shall be activated by a signal from a local override switch on the room temperature sensor or by command from the operator's terminal. At the end of the operator determined time period, the terminal equipment controller shall return to the Unoccupied Mode.
5. Programming of unit shall be as recommended by manufacturer.

C. VAV Air Handling Units:

1. Each air handling unit shall be optimally started and stopped by the control system according to its occupied and unoccupied schedule. The AHU smoke dampers shall open, and then the supply fan shall ramp up to its cooling airflow (CFM).

2. For units utilizing outside air for ventilations, during unoccupied hours and morning startup operation, the motorized outside air damper shall remain closed. When in occupied operation, the outside air damper shall modulate to maintain its minimum required outside airflow (CFM) as measured by a duct airflow station. For units connected to ventilation air units, the motorized isolation damper shall be closed whenever the unit is stopped.
3. A duct static pressure transmitter shall be located at two-thirds the distance down the longest duct run and shall allow the controls to operate the supply fan VFD in order to maintain the duct static pressure setpoint. A duct static pressure high limit switch shall shut down the air handling unit and alarm the control system if its set point is exceeded. Operate units based on supply air static pressure and temperature reset.
4. The air handling unit supply air temperature shall be controlled to maintain its setpoint.
5. AHU duct smoke detectors shall be provided and installed under this section of the Specifications. Wiring the AHU duct smoke detectors to the fire alarm system shall be accomplished by Division 16. Interlock wiring for shutdown of the air handling units for the AHU duct smoke detectors shall be accomplished under this section of the Specifications. The AHU duct smoke detectors will alarm the system in the event that products of the combustion are detected.
6. The AHU will be provided with a filter status airflow switch across the AHU filter bank which will alarm the system when the airflow pressure drop exceeds its setpoint.

D. VAV Boxes with Electric Heat:

1. During the occupied mode, the Terminal Equipment Controller (TEC) modulates the primary supply air damper within user defined separate heating and cooling maximum and minimum air volume settings by sensing the inlet air velocity (CFM).
2. On a rise in temperature above the room cooling setpoint, the Terminal Equipment Controller (TEC) shall modulate open the duct supply air damper to maintain room temperature.
3. Similarly, on a fall in temperature below the room heating setpoint, the Terminal Equipment Controller (TEC) shall modulate the supply duct damper to its minimum position of 50% of rated air flow, and then the electric heating coil shall be modulated to maintain the room temperature.
4. When commanded to change over the Unoccupied Mode, the Terminal Controller shall raise cooling setpoint and decrease the heating setpoint (as appropriate) to operator-determined values.
5. During the Unoccupied Mode, the Terminal Controller shall be reset to the

Occupied Mode for an operator determined time period. This reset shall be activated by a signal from a local override switch on the room temperature sensor. At the end of the operator determined time period, the Terminal Controller shall return to the Unoccupied Mode.

6. The Controls Contractor shall be responsible for providing power wiring to all VAV box controls as required for proper operation.

E. Exhaust Fans:

1. Exhaust fans shall be controlled by the building energy management system, local thermostat, or wall switch as indicated on the contract drawings and equipment schedule. Operate group toilets based on building occupied schedules.

F. Unit Heaters and Water Heaters:

1. Unit heaters and water heaters shall be controlled by the building energy management system or local thermostat as indicated on contract drawings.

END OF SECTION

SECTION 15990 - TESTING AND BALANCING AIR SYSTEMS

PART ONE - GENERAL:

1.01 SCOPE:

- A. The Owner shall employ a testing and balancing firm specialized in total system testing and balancing. The balancing firm shall be a member of the Associated Air Balance Council (AABC) or certified by the National Environmental Balancing Bureau (NEBB). The balancing firm shall provide all labor, equipment, engineering and test equipment required to test, adjust, and balance all heating, ventilating, air-conditioning, and exhaust systems as hereinafter specified.
- B. Approved Testing and Balancing Firm:

Palmetto Air & Water Balance - Greenville, SC

PART TWO - PRODUCTS AND EXECUTION:

- 2.01 The balancing contract shall incorporate the following:
- 2.02 All medium pressure ducts shall be duct air leak tested with less than 5% leakage prior to insulation by the Mechanical Contractor and verified by the TAB Contractor. Note that all VAV systems that include VAV boxes and utilize static pressure sensors for fan operation, regardless of operation static pressure, shall be considered medium pressure and therefore require duct air leak testing.
- 2.03 Test, adjust and balance the complete mechanical system.
- 2.04 Upon completion of the air handling systems, the Contractor shall have an air balancing firm perform the following tests and compile the following information for each item of equipment and submit four bound copies of this information to the Architect for approval.
- 2.05 Install at each piece of mechanical equipment, a "Data Register" showing all significant operating temperatures, pressures, amperes, voltage, brake horsepower, etc. "Data Register" to be enclosed in a vinyl-film holder securely attached to the equipment or wall in immediate area after balance reports have been accepted. See section 2.10 for data to be included in certified report.
- 2.06 All test equipment will be furnished by the Balancing Contractor and will remain his property. All instruments will have been calibrated recently.
- 2.07 The Balancing Firm shall warrant solely that the system will be set to within 10% of the values as established by the plans and specifications, and also adjust to minimize drafts in all areas.
- 2.08 Any changes that are required for the final balancing results as determined by the Balancing Contractor will be provided by the respective Contractors who are to supply and install such equipment under their contractual obligations. Such changes may encompass, but are not necessarily restricted to, the changing of pulleys, belts, dampers, or adding dampers or access panels. The General Contractor shall be responsible for providing access to all devices that are not accessible from a 12' ladder.

2.09 TESTING AND BALANCING PROCEDURE (AIR):

- A. Before starting air balance, check the following items:
 - 1. Check air filters to be sure they are clean and in position.
 - 2. Check for proper belt tension and alignment.
 - 3. Check fan and motor lubrication.
 - 4. Check motor overload protectors or heaters for proper size.
 - 5. Check for proper rotation.
- B. Measure supply air volumes by means of the duct traverse method, taking a minimum of sixteen (16) readings. Seal duct access holes with metal snap-in-plugs. The use of duct tape to seal access holes will not be permitted.
- C. Adjust balancing dampers for required branch duct air quantities. Dampers shall be permanently marked after air balance is complete.
- D. Adjust grilles and diffusers to within 10% of individual requirements specified, and also adjust so as to minimize drafts in all areas.
- E. The total air delivery in any particular fan system shall be obtained by adjustment of the particular fan speed.
- F. The drive motor of each fan shall not be loaded over the corrected full load amperage rating of the motor involved.
- G. All duct systems are to be balanced for lowest static pressure and lowest fan speed possible to deliver required air quantity as required by ASHRAE Standard 90.1 with applicable adopted year.
- H. Unless otherwise noted, adjust quantity of return air from space to pass 90% of air supplied to space.
- I. Where splitter and volume dampers have been provided for balancing of air in ducts, balancing shall be done with register and diffuser volume dampers as fully open as possible.
- J. Do not operate fans during times when construction process or clearing would allow dirt or rubbish to accumulate in the system.

2.10 TESTING OF EQUIPMENT THERMAL PERFORMANCE:

- A. All heating and cooling equipment shall be properly tested for cooling and heating performance based on the specified data on the mechanical equipment schedules. All systems shall be evaluated based on outside air conditions, mixed return air temperature, coil supply air temperature, building supply air temperatures including fan heat and performance based on entering and leaving air temperatures all heat exchangers. All temperature readings shall be recorded in dry bulb and wet bulb (DB/WB) values to indicate total energy transfer.
- B. Ventilation Air Units (VAU): The acceptable tolerance for the coil leaving air temperature conditions for ventilation air units (DB/WB) during design conditions is 0.5 degrees F above stated design values on the schedule. Any ventilation air unit not meeting the coil leaving air temperature shall be noted as a deficiency in the report.
- C. Packaged/Applied VAV Units: The acceptable tolerance for the coil leaving air temperature

conditions for ventilation air units (DB/WB) during design conditions is 1 degree F above stated design values on the schedule. Any unit not meeting the coil leaving air temperature shall be noted as a deficiency in the report.

- D. Note: Any unit with scheduled coil leaving air temperatures on the plans that are not specified as Ventilation Air Units (VAU) shall comply item

2.10 CERTIFICATION:

- A. Furnish to the Architect/Engineer two (2) copies of the following data, signed by an authorized representative:
1. Room
 2. Supply or Return Size
 3. Design CFM
 4. Measured CFM
 5. Percent of Design CFM
 6. Outside air conditions (DB/WB)
 7. Mixed air return conditions (DB/WB)
 8. Coil leaving temperature (DB/WB)
 9. Building supply temperature including fan heat (DB/WB)
 10. Heat exchanger performance EAT/LAT (DB/WB) as applicable
 11. Hot gas reheat performance to produce neutral air (DB) as applicable
 12. Coil delta T in heating (DB)
 13. Voltage/amps/phase (Design/Actual)
 14. RPM
 15. BHP actual / Nameplate H.P.
 16. Turns open / ECM fan settings / multi speed motor settings
 17. ESP. Design/Actual
 18. Installed compressor tonnage
 19. Static pressure operating set point at remote sensor (VAV systems)
 20. VAV Box maximum and minimum operating setpoints (VAV systems)
 21. Verification of BAS Static pressure reset programming (VAV systems)
 22. Verification of BAS supply air temperature reset programming (VAV systems)
 23. Outside air volume verification, both fixed and variable volume, as scheduled

Note that the above information shall be included in the certified report as a minimum. Additional information shall be provided as required for the equipment utilized.

2.11 FINAL AIR BALANCE:

- A. Perform final air balance after building is occupied. On final air balance adjust air quantities as required to maintain space temperatures in building at 74 degrees (summer) and 70 degrees (winter) plus or minus 2 degrees F. Submit data sheets on recorded temperatures. Indicate time of day and outdoor temperature on data sheets.
- B. A preliminary Test and Balance Report shall be issued to the Mechanical Contractor and Engineer prior to the issuance of the final Testing and Balancing Report outlining all deficiencies in the installed system. These listed deficiencies shall be corrected and/or resolved prior to finalizing the Test and Balance Report after building occupancy of required.
- C. Final Air Balance shall occur prior to Office of School Facilities inspection as applicable.

E. The General Contractor shall account for TAB in the construction schedule. Failure to properly prepare systems for TAB with sufficient time prior to final inspections and/or complete deficiencies found causing delays will result in additional costs billed to the General Contractor.

END OF SECTION

DIVISION NO. 16 – ELECTRICAL

SECTION 16010 - GENERAL REQUIREMENTS

PART ONE - GENERAL:

1.01 SCOPE:

- A. The General and Special Conditions are a part of this Section of the Specifications.
- B. Provide all labor, equipment, material, and operations required for complete, safe, and quietly operating electrical systems in accordance with Specifications and Drawings and subject to terms and conditions of the contract.
- C. Drawings and Specifications are complementary and what is called for by either shall be as binding as if called for by both.
- D. Examine other Drawings and Specifications and bring to the attention of Architect prior to bid time any omissions or discrepancies in this DIVISION.

1.02 CODES, RULES, PERMITS, FEES, AND APPLICABLE PROVISIONS:

- A. Comply with the 2005 edition of the National Electrical Code, 2006 International Building Code, 2003 Life Safety Code, and Municipal Code requirements. In case of conflict, Municipal Code shall govern.
- B. The Contractor shall give all requested notices, obtain necessary permits, and pay all required fees.
- C. Deliver to Architect permits and certificates.

1.03 DRAWINGS:

- A. Project Drawings: The Drawings accompanying this Specification are generally diagrammatic and do not show all details of bolts, nuts, connections, and the like required for the complete system, and do not indicate the exact location of conduit, fixtures, equipment, etc., unless definitely dimensioned or noted. While these Drawings shall be followed as closely as possible, all dimensions shall be checked at the building and any necessary changes shall be made to accord with structural and architectural conditions, equipment to be installed or with the work of the different trades, without additional cost to the Owner, and as directed by the Architect. Any component item which is necessary for the proper operation of any system under this contract shall be furnished and installed by the Contractor without extra charge.

1.04 EXAMINATION OF CONDITIONS:

- A. It is understood and agreed that the Contractor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality, and quantity of the materials to be encountered, the general and local conditions, and to all other matters which can affect the work under this contract.

1.05 COORDINATION:

- A. Coordinate work with other trades to avoid interferences and establish necessary space requirements and tie-ins for each trade.
- B. Prior to starting installation, furnish to the General Contractor and all Sub-Contractors concerned, copies of approved shop drawings showing location of equipment, piping, and etc.
- C. Schedule periodic meetings with other trades before and during installation to avoid conflicts and assure that conduits and equipment are installed in the best manner, taking into consideration head-room, maintenance, appearance, and replacement.

END OF SECTION 16010

SECTION 16040 - GENERAL COMPLETION, ELECTRICAL

PART ONE - GENERAL:

1.01 GENERAL REQUIREMENTS FOR INSTALLATION:

- A. Piping, fixtures, equipment, etc., shall be located to avoid interference with structural and architectural conditions, or with the work of different trades. Provide off-sets where necessary to avoid footings, piers, columns, beams, windows, other piping, mechanical systems, and other systems, etc., specifically inform the General Contractor as to the correct size and location of all chases, openings, supports, sleeves, etc., required for the system. Furnish and install sleeves, inserts, bolts, etc., and arrange for the cutting of walls, floors, roofs, etc., and the proper closing of all openings. Cutting of construction, where unavoidable, must be done by the General Contractor, but shall be paid for by the electrical contractor. No part of the building may be broken out, cut, burned, or permanently removed without the approval of the Architect.

PART TWO - PRODUCTS:

2.01 WORKMANSHIP AND MATERIALS:

- A. Workmanship shall be of the best quality and none but competent mechanics skilled in their trades shall be employed. The Contractor shall furnish the services of an experienced superintendent, who will be constantly in charge of the erection of the work, until completed and accepted.
- B. Unless otherwise hereinafter specified, all materials and equipment shall be new, of best grade, and as listed in printed catalogs of the manufacturer. Each article of its kind shall be the standard product of a single manufacturer.
- C. The Architect shall have the right to accept or reject material, equipment and/or workmanship, and determine when the Contractor has complied with the requirements herein specified. Where departures from indicated arrangements are required, written approval for such changes shall be obtained from Architect's representative.
- D. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.
- E. All material and equipment used on this project shall be stored in a weatherproof, bonded warehouse. Contractor shall submit insurance certificate to the Architect prior to storing any materials or equipment. No equipment or materials used on this project shall be stored outside exposed to the weather. Before final payment can be made, a notarized statement with the material invoiced to the Owner must be furnished to the Architect.

2.02 DIVISION OF WORK:

- A. Coordinate all opening locations with General Contractor, see paragraph 2.03.

- B. The electrical contractor shall provide concrete foundations, curbs and pads for electrical equipment and fixtures. Unless otherwise noted, set all floor and/or ground mounted equipment on 6" high concrete pads reinforced with 6 x 6 10/10 mesh. Pads shall be approximately 6" larger than equipment base and have 1" x 1" chamfer on all edges. Pads to have carborundum brick rubbed finish. Surface finish shall be uniformly smooth.
- C. General Contractor will provide flashing of conduits into roofing. The electrical contractor shall provide counterflashing.
- D. Provide complete power wiring and connections for mechanical systems specified under the mechanical specifications. This work includes all raceways, conductors, outlets, and pull boxes, line voltage, on-off switches where indicated and disconnecting means as indicated and required by applicable codes. Where magnetic motor starters (controllers) are furnished by others, install and wire complete; where controllers are provided already mounted on equipment, wire complete. In all cases, provide power wiring to controller and load controlled. Wire sizes between controllers and loads shall be the same as feeder size to controller, do not reduce. Make all connections and color code per this DIVISION. Safety switch enclosures shall be NEMA Type 3R outdoors and wet locations; NEMA Type 1 elsewhere. Not included in this DIVISION are temperature control wiring, equipment control wiring and interlock wiring required to operate the mechanical system. Refer to the mechanical specifications for a summary list of types of equipment provided under that DIVISION. The electrical contractor shall provide outlet box for thermostat with 3/4" conduit to corresponding mechanical unit. The electrical contractor shall provide a 3/4" empty conduit between indoor air handling unit and exterior heat pump on split system units; this conduit is in addition to thermostat conduit noted above.

2.03 OPENINGS - CUTTING, REPAIRING:

- A. The electrical contractor shall cooperate with the work to be done under other Sections in providing information as to openings required in walls, slabs, and footings for all conduits and equipment, including sleeves, where required.
- B. All drilling, cutting, and patching required for the performance of work under this Section shall be performed by the General Contractor and the cost thereof shall be borne by the electrical contractor.
- C. Holes in Concrete: Sleeves shall be furnished, accurately located and installed in form before pouring of concrete. The electrical contractor shall pay all additional costs for cutting of holes as the result of the incorrect location of sleeves. All holes through existing concrete shall be either core drilled or saw cut. All holes required shall have the approval of the Structural Engineer prior to cutting or drilling.

2.04 EXCAVATION AND BACKFILL:

- A. General: The Contractor shall do all excavating and backfilling necessary to receive the work shown on the drawings.

Excavations shall be made to the proper depth, and the trenches shall be graded uniformly to provide solid bearing along the entire length of the conduit. All trenches shall be excavated so that conduits will have at least (6) inches clearance on each side. Conduits in fill or loose sand shall have trench bottom tamped to 95% maximum density compaction prior to laying conduits.

- B. Backfilling: Do not fill any trenches until all conduits have been inspected. After the work is installed, tested, inspected, and approved, the trenches shall be refilled in six-inch layers with clean, damp earth, with each layer thoroughly tamped before proceeding with additional layers. Remove from site all excess earth, rock and other debris resulting from excavation and backfill work.

2.05 NAMEPLATES:

- A. On all panelboards, disconnect switches, transformers, and enclosures provide engraved phenolic plastic nameplates. Unless otherwise noted, nameplates to be 1/16" thick plastic with 1/4" high white letters on black background. Hand lettering, typing under tape, embossed letters on plastic, etc., will not be acceptable
- B. Attach nameplates with two rivets.

2.06 CLEANING EQUIPMENT AND MATERIALS:

- A. Provide for the safety and good condition of all materials and equipment until final acceptance by the Owner. Protect all materials and equipment from damage. Provide adequate and proper storage facilities during the progress of the work.
- B. All fixtures, conduits, finished surfaces, and equipment shall have all grease, adhesive labels, and foreign materials removed.

2.07 CLEANING UP:

- A. Remove from the premises all unused material and debris resulting from the performance of work under this Section.

2.08 DAMAGES:

- A. Cost of repairing damage to building, building contents, and site during construction and guarantee period resulting from this work is a part of this contract.

2.09 TEST PERFORMANCE:

- A. Upon completion of the work, the system shall be free of faults, including short circuits, grounds, and open circuits, and loads balanced across phases to obtain minimum neutral current in all feeders and branch circuits. All communications systems shall operate at a standard representative of the best state of the art for the particular system involved. All life safety systems shall be demonstrated and certified as to operation in compliance with the codes and the intent of these Specifications. Test system in the presence of the Engineer or his representative,

and operate to comply with the true intent of Plans and Specifications. Defray cost of all adjustments required to correct deficiencies; replace defective material and equipment, do not repair.

2.10 FINISHED PLANS:

- A. As-built Drawings: Upon completion of the work, the Contractor shall furnish and deliver to the Owner two (2) sets of as-built drawings to correspond in size to the tracings, showing among other things, layouts of utility systems and functional systems (such as public address, fire alarm and telephone). All pertinent dimensions and elevations of buried work shall be given.

2.11 INSTRUCTIONS:

- A. Provide a hard back, three-ring file folder containing all warranties, catalog data and the manufacturer's recommendations and the frequency with which each is to be done. Each sheet shall be initialed by the manufacturer's agent as being correct. Provide columns on each sheet so that they may be dated by maintenance personnel when each individual function is performed. Contractor shall furnish a typed maintenance manual in a hard back, three-ring binder explaining all maintenance functions. The Contractor shall instruct and demonstrate each maintenance function to the Owner's Representative. The Owner's Representative shall in turn sign the maintenance sheets indicating his understanding of the instructions. Coordinate all equipment start-ups with the Owner, so that they may be present.
- B. The Contractor shall instruct the Owner's Representative in complete detail as to the proper operation of the overall systems. Advise the Owner as to where to order common replacement items. Deliver to the Owner the manufacturers' agent's name, address, and the telephone number of each piece of equipment.

2.12 GUARANTEE:

The Contractor agrees:

- A. To correct defects in workmanship, materials, controls, equipment, and operation of the system for a period of one (1) year from the date of acceptance.
- B. To remove any item not specified or given written approval and replace it with the specified item.
- C. That the systems installed will safely, quietly, and efficiently perform their respective functions in accordance with the design.

END OF SECTION 16040

SECTION 16050 - BASIC MATERIALS AND METHODS

PART ONE - GENERAL:

1.01 APPROVALS AND SUBSTITUTIONS:

- A. All requests for substitutions shall be submitted so as to be received by the Engineer at least ten (10) calendar days before bid date. Approved material will be listed in addendum form.
- B. Contract prices shall be based on material and equipment as specified, unless written approval is obtained for any deviations. Requests for substitutions before bid date may be submitted by Contractors or by Equipment Manufacturer's Representatives.
- C. Requests for approvals should be submitted in the form of a letter (with one copy minimum) on a letterhead of submitting firm, along with a self-addressed, stamped, return envelope. Letter shall be addressed to the Engineer and referenced to this project.
- D. If there are no deviations between the items submitted and the plans and specifications, then the submittal letter should contain the statement, "Items are in accordance with plans and specifications with no deviations". An item with deviations from the plans and specifications may be submitted for approval consideration. Letter should then state, "Item submitted is in accordance with plans and specifications, except for the following deviations." Deviations should then be listed in itemized form.
- E. Items approved shall not be construed as authorizing deviations from the plans and specifications. Contractor shall be responsible for verifying all dimensions with available space conditions with provisions for proper access, maintenance, and part replacement, and for coordination with other trades - mechanical, plumbing, structural, etc., for proper services and construction requirements.
- F. Where such approved deviations require a different quantity and arrangement of wiring, conduit and equipment from that specified or indicated on the drawings, the Sub-Contractor shall furnish and install any such structural supports, controllers, starters, electrical wiring and conduit, and any other additional equipment required by the system, at no additional cost to the Owner.

PART TWO - PRODUCTS AND EXECUTION:

2.01 MANUFACTURER'S INSTRUCTIONS:

- A. Prior to purchasing equipment, procure product manufacturer's application, installation, and operating instructions for use in conjunction with the system design drawings and specifications during construction. If there exists any conflict between the manufacturer's publications and the design drawings and specifications, immediately notify the Engineer, in writing. Upon notification by the Engineer, proceed in accordance with his instructions.

2.02 Operations and Maintenance Manuals:

- A. Prior to project closeout, the Sub-Contractor shall submit for approval, a completed operations and maintenance manual to the engineer for review. The operations and maintenance manual

shall contain at least the following items. Exclusion of items is permissible only when the scope of electrical work outlined in these contract documents does not include an item listed below:

1. Electrical Contractor's warrantee / guarantee showing dates of acceptance and duration.
2. Product data sheets, diagrams, performance curves, and charts published by the manufacturer. Complete electrical characteristics and manufacturer's part numbers shall be provided for all equipment.
3. Charts which explain the conduit color coding scheme used for conduit and wire throughout the facility.
4. Insulation resistance test results for all feeders.
5. Operating & users instruction manual(s) for Lighting control systems
6. Final circuit breaker trip and time delay settings
7. Chart listing fuse ampacity, type and manufacturer's part number installed in each disconnect.
8. Operating & users instruction manual(s) for any generators, transfer switches, or lighting inverters.
9. Copy of the UL "Master Label" for any lighting protection system required elsewhere in the contract documents.
10. Operating & users instruction manual(s) for the fire alarm system.
11. As built shop drawings and plans for the fire alarm system indicating device locations and all calculations.
12. Digital media with as built fire alarm system program and all required programming password & user names.
13. Copy of the fire alarm system paperwork required by the NFPA to be completed by the fire alarm system installer.
14. Operating & users instruction manual(s) for the security, telephone, public address, or sound augmentation and reinforcement systems.
15. A copy of the seismic submittal for electrical installation signed and sealed by the seismic engineer.

2.03 SHOP DRAWINGS:

- A. The Sub-Contractor shall submit for approval detailed shop drawings of all equipment and all material required to complete the project, and no material or equipment may be delivered to the job site or installed until the Sub-Contractor has in his possession the approved shop drawings for the particular material or equipment. The shop drawings shall be complete as described herein. The Sub-Contractor shall furnish the number of copies required by the General and Special Conditions of the contract, but in no case less than six (6) copies.
- B. Prior to delivery of any material to the job site, and sufficiently in advance of requirements to allow Architect ample time for checking, submit for approval detailed, dimensioned drawings or cuts, showing construction, size, arrangement, operating clearances, performance characteristics and capacity. Each item of equipment proposed shall be a standard catalog product of an established manufacturer and of equal quality, finish, and durability to that specified.
- C. Samples, drawings, specifications, and/or catalogs submitted for approval shall be properly

labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, Contractor's name, and name of project.

- D. Catalogs, pamphlets, or other documents submitted to describe items on which approval is being requested, shall be specific and identification in catalog, pamphlet, etc., of item submitted shall be clearly made in ink. Data of a general nature will not be accepted.
- E. Approval by the Architect and/or Engineer of shop drawings for any material, apparatus, devices, and layouts shall not relieve the electrical contractor from the responsibility of furnishing same of proper dimension, size, quantity, quality, and all performance characteristics to efficiently perform the requirements, and intent of the contract documents. In addition, approval shall not relieve the electrical contractor from responsibility for errors of any sort on the shop drawings. If the shop drawings deviate from the contract documents, the electrical contractor shall advise the Architect and/or Engineer of the deviations, in writing, accompanying the shop drawings, including the reasons for deviations.
- F. Failure of the Sub-Contractor to submit shop drawings in ample time for checking shall not entitle him to an extension on contract time, and no claim for extension by reason of such default will be allowed.
- G. The table on the following pages shall be included in the front of the shop drawing submittal. Sections of the specifications that are included in the specifications manual for this project shall require a submittal for each item listed. Incomplete or partial submittals shall be rejected.

Spec Section	#	Item Description
Site Lighting	1	Landscape lighting fixtures
	2	Lamps
	3	Type FSIFP outlet boxes
General Completion	1	Insurance Certificate indicating that stored materials are held in a bonded warehouse
	2	Superintendent's name, job trailer phone and fax numbers
	3	Name Plates type and attachment method
Conduit	1	Conduit , Cables, Tubing
	2	Supports
	3	Fittings and connectors
	4	Expansion joints
	5	Ground Bushings
	6	Tracing tape
	7	Sealants
	8	Fire Wall Penetrations (Provide U.L. Listing Number)
Busways	1	Busway
Under floor Ducts	1	Duct system sharing joiners, spaces, covers, supports, seats, etc.
Surface Metal Raceway	1	Surface raceway system - include all components
Wires and Cables	1	Wire – minimum size, manufacturer, insulation type
	2	Connectors and lugs
Outlets, Switches & Boxes	1	Outlet boxes
	2	Floor Boxes
Wall Switches	1	Switches (Also indicate color, load type, terminal type, and rating)
	2	Plates
Receptacles	1	Receptacles
	2	Plates
Lighting Control Relay System	1	Relay cabinet and relay modules
	2	Override switches
	3	Cables
	4	Photocells
Dimming System	1	Dimmer panel and dimmer modules
	2	Control consoles

Spec Section	#	Item Description
Lighting Control	1	
Sensors		Sensors
	2	Power Packs
Motor Starter	1	Motor starters
Motor Control Center	1	
		Documentation showing installers experience with submitted system
	2	Motor control center with all components and appurtenances.
Panel boards	1	
		Panel boards (also indicate short circuit current rating and withstand rating)
Fuses	1	
		Fuses
	2	Fuse Cabinet
Main Switchboard	1	Main Switchboard (also indicate short circuit current rating and withstand rating)
Motor & Circuit Disconnects	1	Disconnect Switches
Dry Type Transformers	1	Dry type transformers
Pad Mounted xformers	1	Pad mounted transformer
Generator Set	1	Generator
	2	Transfer Switch
	3	Vibration Isolation
	4	Mounting / pad dimensions
	5	Cooling system
	6	Exhaust system
	7	Control system
	8	Engine heater
	9	Battery and charger
	#	Main line circuit breaker
External TVSS / SPD	1	Surge Protective Devices
Underground Electrical Work	1	Ground rods
Service and Metering	1	Meter sockets
	2	CT cabinets
Grounding	1	Grounding devices and fitting
	2	Ground rods
Lighting Fixtures	1	Light Fixtures

Spec Section	#	Item Description
	2	Lighting Control Systems
	3	Arc Keeper Devices
	4	Generator Transfer / Switch bypass devices (GTD)
	5	Occupancy Sensors
	6	Lighting Inverter Systems
Exterior Sports Lighting Poles	1	Data and calculation showing that submitted pole complies with contract documents
	2	Data and calculation showing that submitted foundation complies with contract documents
	3	Poles
	4	Foundations
	5	Lighting protection system
Emergency Lighting System	1	Inverter units
	2	Battery charger
	3	Batteries
	4	Cabinets
Fire Alarm System	1	Fire Alarm System Control Panel
	2	Power Supply / Batteries
	3	Smoke Detectors / Heat Detectors
	4	Addressable modules
	5	Cables and Wiring
	6	Manual Pull Stations
	7	Notification Devices
	8	Documentation that certifies that the installer has been factory trained on the submitted system.
Security System	1	Control panel
	2	Control key pads
	3	Enclosure
	4	Magnetic door contacts
	5	Motion detector
	6	Sounder
Office phone Sys.	1	Telephone system control cabinet
	2	Hand/desk sets
	3	Wire and cables

Spec Section	#	Item Description
Integrated Telecomm / Telemedia Systems	1	Integrated telephone, public address and telemedia control system
	2	Outline drawing of system control cabinet
	3	FCC registration number with signal equivalent
	4	Wiring diagrams showing typical connector
	5	Certification of completion and installation and service training from system manufacturer
Classroom Intercom, Master-clock & Program System	1	Console
	2	AM-FM tuner, cassette player
	3	AM-FM antenna
	4	Administrative telephone
	5	Staff telephone
	6	Room call-in switch
	7	Digital master clock
	8	Speakers/ back boxes
	9	Exterior speakers
	10	Cable
Public Address System Replacement	1	Equipment cabinet
	2	Control panel
	3	AM-FM tuner, cassette player
	4	Power amplifier
	5	Selection panels
	6	Master clock and program distribution system
	7	Room call-in switch
	8	Speakers/ back boxes
	9	Exterior speakers
	10	Cable
Public Address Communication Sys (w/phones)	1	FCC registration number of the submitted system
	2	Data sheets for all equipment being provided
	3	Internal control cabinet drawings showing internal block diagram connections
	4	Wiring diagrams showing typical field wiring connections

Spec Section	#	Item Description
	5	Documentation that installer maintains service and parts for submitted system
Sound Augmentation Systems	1	Microphones, receptacles, extension cables and stands
	2	Mixer/ pre-amp
	3	Amplifiers
	4	Cables
	5	Equipment housing
	6	CD player
	7	Monitor headphone
	8	Equalizer
	9	Crossover network
	10	High frequency horns and drivers
	11	Low frequency loudspeaker and enclosure
Sound Reinforcement System	1	Microphones, receptacles, extension cables and stands
	2	Mixer/ pre-amp
	3	Equalizer
	4	Crossover network
	5	Amplifier
	6	speakers
	7	Equipment housing
	8	Cable
Athletic Field Sound Augmentation System	1	Microphones
	2	Amplifiers / mixers
	3	Speakers & mounting brackets
	4	Equipment housing
	5	Cd players/mixers/compressors/power conditioners
	6	Cables / wall plates
Coaches' Communication Sys	1	Master station
	2	Headset 1 belt system
	3	Head coach switch module
	4	Extension cables
Television Distribution System	1	Block diagram of system showing catalog numbers of amplifiers, splitter, taps and cables
	2	Head end amplifiers

Spec Section	#	Item Description
Media Management Center and Video Distribution	3	Noise filters
	4	Pre-amplifiers, re-amplification and pads
	5	Coaxial cable
	1	Internal control cabinet block diagram
	2	Wiring diagrams showing typical field wiring connections
Telecom Infrastructure	3	FCC registration number
	4	Data sheets for all equipment being provided
	5	Cable
	1	Cable trays and supports
	2	Fire wall penetrations
	3	Grounding equipment
	4	Hand Hole Boxes and Covers
Vibration & Seismic Control	5	Cables
	6	Communication outlets
	7	Grounding equipment
	1	Complete set of calcs and shop drawings with PE seal certifying that the design meets seismic req.
	2	Seismic design errors and omissions insurance certificate.

END OF SECTION **16050**

SECTION 16111 - CONDUIT

PART ONE - GENERAL:

- 1.01 Minimum size conduit shall be ½". Other sizes shall be as indicated on the Plans, or required by the National Electrical Code for number and size of conductors installed. All conduit joints shall be cut square, threaded, reamed smooth and drawn tight. Bends or offsets shall be made with standard conduit ells, field bends made with an approved bender or hickey, or hub-type conduit fittings. Number of bends per run shall conform to National Electrical Code limitations. All wiring, regardless of voltage, shall be in conduit.

PART TWO - PRODUCTS:

2.01 RIGID METAL CONDUIT (OR IMC):

A. Shall be used for:

1. Service.
2. Exposed branch circuits where subject to damage.
3. Branch circuits underground where outside of building line if not installed under 3" of concrete.

2.02 RIGID NONMETALIC CONDUIT (RNC):

A. Shall be used for:

1. Branch and feeder circuits underslab where inside of the building line (ground floor only).
2. Branch circuits underground where outside of the building line and below at least 3" of concrete or within duct banks

B. Shall be schedule 40 PVC.

2.03 PVC COATED RIGID GALVANIZED METAL CONDUIT

A. Shall be used for:

1. Corrosive exterior environments around cooling towers.

2.04 ELECTRICAL METALLIC TUBING (EMT):

A. Shall be used for:

1. All areas not listed in paragraphs 2.01, 2.02 and 2.03.

PART THREE - EXECUTION:

3.01 RACEWAYS:

- A. Horizontal and vertical conduit runs may be supported by one hole malleable straps, clamp-backs or other approved devices with suitable bolts, expansion shields, or beam clamps for mounting to building structure or special brackets. Adjustable hangers may be used to suspend large conduits when separately located. If adjustable trapeze hangers are used to support groups of parallel conduits, U-bolt or similar type clamps shall be used at the end of a conduit run and at each elbow. J-bolts or approved clamps shall be installed on each third intermediate trapeze hanger to fasten each conduit. Hangers shall be painted with two coats of oil paint. Where excessive corrosive conditions are encountered, hanger assemblies shall be protected, after fabrication, by sheradizing or galvanizing, special paint, or other suitable preservative methods. The use of perforated iron straps, wire, etc., for supporting conduits will not be permitted. The required strength of the supporting equipment and the size and type of anchors shall be based on the combined weight of conduit, hanger, and cable.
- B. Conduit installed in exterior wall shall be routed in stud or block cavity not in air spaces between block and brick.
- C. Where any run of rigid conduit may change to a run of EMT, or vice-versa, such a change shall be made in a junction or outlet box, as elsewhere required, with each conduit terminating separately therein.
- D. Conduit shall be continuous from outlet to outlet and from outlets to cabinets, pull boxes or junction boxes, and shall be secured to all boxes with locknuts and bushings in such a manner that each system shall be electrically continuous throughout. Conduit ends shall be capped to prevent entrance of foreign materials during construction.
- E. Conduit terminals at cabinets and boxes shall be rigidly secured with locknuts and bushings as required by the National Electrical Code and other electrical codes. All conduit bushings shall be of the insulating type with two locknuts.
- F. All conduit shall be installed complete before conductors are pulled in. All conduit shall be cleaned and free of foreign matter inside before any conductors are pulled in. A run of conduit which has become clogged shall be entirely freed, or shall be replaced.
- G. A pullwire shall be left in each run of empty conduit. Pullwire shall be 16 gauge galvanized steel.
- H. Run all conduit at right angles to or parallel to walls of building.
- I. Use short pieces, approximately two feet, of flexible metal conduit to connect motors and other devices subject to motion and vibration.
- J. Support conduit and secure to forms when cast in concrete so that conduit will not be displaced during pouring of concrete. Stuff boxes and cork fittings to prevent entrance of contaminants during concrete pouring and at other times during construction prior to

completion of conduit installation.

- K. Use expansion fittings with copper bonding jumpers to assure ground continuity across expansion joints in walls, floors, and ceilings. Use double locknuts and bushings on panel feeders at panel enclosures.
- L. Install grounding bushing on all conduit entering or leaving main switchboard. Connect each bushing to switchboard ground bus with a separate #4 bare copper conductor, lugged to bus.
- M. Any EMT connectors must be all steel compression type with insulated throat. EMT couplings shall be all steel compression type. No cast fittings of any type will be accepted.
- N. Color coding shall be provided every 8'-0" on conduit or factory colored conduits shall be used and shall be as follows:
 - 1. 480 volt, single and three phase - Orange
 - 2. 208 volt, single and three phase - Green
 - 3. 120 volt - Yellow
 - 4. Fire alarm system - Red
 - 5. Motor and other control systems - Blue
 - 6. Telephone and communications - White
 - 7. Security - Brown.
- O. All firewall penetrations shall be properly fireproofed with U.L. listed system that conforms to the wall or floor type, wall or floor fire rating, and to the size and number of conduits penetrating the wall or floor.
- P. Conduit shall not be routed within 1.5" of the underside of a corrugated metal roof deck and shall not be fastened to or supported from the underside of a corrugated metal roof deck.
- Q. Underground conduits outside of the building line shall be installed as follows:
 - 1. Conduits shall be a minimum of 30" below grade.
 - 2. Rigid non-metallic conduit shall have an electronically detectable tracing tape installed above them.
 - 3. Rigid non-metallic conduit bends shall be pre-manufactured "factory" bends or field made bends using "hot box" style conduit benders.

4. Rigid non-metallic conduit shall be installed below a minimum of 3" of concrete
 5. Rigid non-metallic conduit joints shall be made per the manufacturer's instructions including use of primer prior to application of glue.
- R. Underground conduits inside of the building line shall be installed as follows:
1. Conduits shall be run under vapor barrier and shall be routed or shall be installed deep enough to prevent penetration of building footers or other structural supports.
 2. Conduit shall have rigid steel 90's installed where penetrating slab. Rigid steel 90's shall have two coats of asphaltum and all wrench marks and etc., shall be touched-up after conduit has been assembled.
 3. Rigid non-metallic conduit joints shall be made per the manufacturer's instructions including use of primer prior to application of glue.
- S. Conduits shall not be installed within the concrete slabs of intermediate floor levels.
- T. Conduits which are subjected to large temperature differences or those which enter the building from the exterior shall be sealed. The sealing method shall be equal to poly water FST. Conduits to be sealed include:
1. Those which enter the building from the exterior.
 2. Those which enter coolers or freezers.
 3. Those which pass through unconditioned portion of the building.
 4. Those which supply rooftop equipment.
- U. Conduits shall not be installed above or on top of a roof without expressed permission of the engineer. Conduits serving rooftop equipment shall be routed within the building and penetrate the roof plane vertically at the equipment being supplied.
- V. Conduits installed in masonry construction shall be routed vertically in block cavities. They shall not be routed horizontally for more than 24" within block wall where such installation requires excessive cutting or notching of each block.
- W. Where surface mounted conduits are permitted, they shall be painted to match the adjacent wall surfaces.
- X. Bridging between steel joist framing shall not be used to support conduits.
- Y. Parallel sets of conductors routed below grade shall be installed in duct banks.
1. Duct bank shall be encased in concrete with at least three inches of concrete at the top and bottom and two inches on each side. A horizontal and vertical separation between the ducts of 3 inches shall be maintained

by installing thermoplastic high impact spacers at 4 foot intervals. Spacers shall be equal to Carlon #SPxW30-2.

2. Stagger the joints of the conduits by rows and layers so as to provide a duct line having the maximum strength.
 3. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs.
 4. As each section of a duct line is completed, draw a testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the size of the conduit through each conduit, after which draw a brush having the diameter of the conduit, and having stiff bristles through until the conduit is clear of all particles of earth, sand, and/or gravel; then immediately install conduit plugs.
 5. Conduits shall be sized as indicated on project drawings. Provide steel reinforcing in concrete duct bank as indicated on drawings. Separate conduit as indicated.
 - 6.) Install the top of the concrete envelope not less than 30 inches below grade or as indicated on project Drawings.
- Z. Concrete used to cover below grade conduits shall be 3000 psi concrete with 1 inch maximum aggregate

END OF SECTION 16111

SECTION 16120 - WIRES AND CABLES

PART ONE - GENERAL:

1.01 CONDUCTORS:

- A. Provide soft-drawn copper conductors in raceways as shown on Drawings. Conductors shall conform to the latest NEC requirements and meet ASTM specifications, with 75/90 degree C, Type THWN/THHN insulation.
- B. All wire and cable shall be new, with size, grade of insulation, voltage and manufacturer's name permanently imprinted on outer covering at regular intervals, and delivered to the job site in complete coils and reels. All wires sized #10 and smaller shall be solid, and sizes #8 and larger shall be stranded.

1.02 COLOR CODING:

- A. Wire and cable shall have colored insulation in sizes #10 and smaller; and in sizes #8 and larger shall be color coded on the job using Scotch color tape, E-Z code, Brady, or equal wire markers. Color coding shall be as follows:

240 DELTA/120 or

208 WYE/120 VOLT SYSTEM

480 WYE/277 VOLT SYSTEM

Phase A - Black

Phase B - Red

Phase C - Blue

Neutral - White

Grounding - Green

Phase A - Brown

Phase B - Orange

Phase C - Yellow

Neutral - Gray

*Provide permanent identification of color coding in each branch circuit panelboard as per NEC.

PART TWO - PRODUCTS:

2.01 CONDUCTORS:

- A. Wire and cable shall be as manufactured by Colonial Wire & Cable, Essex, Southwire Co., General Cable, Rome Cable, or approved equal.

2.02 CONNECTORS:

- A. Connectors, lugs, and terminals, shall be as manufactured by 3M Company, Ideal, Anderson, Thomas & Betts, OZ Electrical Mfg. Co., or approved equal.

PART THREE - EXECUTION:

3.01 CONDUCTORS:

- A. Minimum wire size for all branch circuits shall be #12 except where indicated otherwise. If the distance from the panelboards to the first outlet exceeds 50 ft., the minimum size conductor for this run shall be #10. If the distance from the panelboards to the first outlet exceeds 100 ft., the minimum size conductor for this run shall be #8. If in special cases this distance must be exceeded, larger conductors of sizes noted on the plans shall be installed.
- B. Do not pull conductors before completion of masonry, concrete, and other trades which generate dust and debris.
- C. Wire and cables shall be suitably protected from weather during storage and handling and shall be in good condition when installed.

3.02 TERMINATIONS:

- A. Conductors #8 and larger shall be connected to equipment by means of pressure type mechanical lugs. Where multiple conductors are connected to the same terminal, each conductor shall be provided with an individual lug.
- B. Solderless connectors of the proper type shall be used for all wiring connections. Where compression type connectors are noted on the plans and in the specifications, they shall be installed with approved hydraulic tools to assure a permanent, mechanically secure, high-conductivity joint. Where soldered joints are specified, the cable joint shall be mechanically strong before soldering. Solder shall be carefully applied without use of acid. Soldered connection shall be wrapped with rubber and friction or insulating plastic tape in a manner approved for circuit voltage.

3.03 TAPS AND SPLICES:

- A. All cable taps, and splices shall be made secure with solderless pressure type connectors, unless otherwise specified. Where compression type connectors are noted on the plans and in the specifications, they shall be installed with approved hydraulic tools to assure a permanent, mechanically secure, high-conductivity joint. Where soldered joints are specified, the cable joint shall be mechanically strong before soldering. Solder shall be carefully applied without use of acid. Soldered connection shall be wrapped with rubber and friction or insulating plastic tape in a manner approved for circuit voltage.
- B. All high-voltage conductor and cable splices, connections, and terminations shall be made with termination or splicing kits containing the necessary connectors and insulating materials for the specific cable size and type involved.
- C. Where conductors are to be connected to metallic surfaces, the coated surfaces of the metal shall

be polished before installing the connector. Lacquer coating of conduits shall be removed where ground clamps are to be installed.

- D. Join conductors with twist on wire connectors sized for the number and gauge of conductors or by soldering, brazing, or welding. Tape all soldered or brazed connections or cover with approved prefabricated insulating devices to provide insulation resistance at the connection equal to that of the wire. Make splices in boxes or fittings only. Push in type wire connectors shall not be used.

3.04 INSULATION RESISTANCE TESTING

- A. All panel board and switchboard feeders shall be tested prior to energizing. 480V feeders shall be tested at 1000 VDC, 208V and 240V feeders shall be tested at 500 VDC.
- B. All current carrying and neutral conductors in every set of conductors shall be tested. Each current carrying and neutral conductor shall be tested to ground and to each other.
- C. All resistance measurements shall be recorded after 60 seconds and all measurements shall be temperature corrected to 60 degrees F.
- D. For each test measurement, the electrical contractor shall record the following information:
Project name, date, temperature, humidity, testers name, testing device manufacturer and model number, feeder origin and termination points, test voltage, set number (for parallel feeders), conductor length, conductor size, measurement origin and termination (for example "A phase to ground "or" A phase to B phase"), insulation resistance in meg-ohms per foot at 60 degrees F, and the signature of the tester. A sample form is attached and a spreadsheet which calculates the corrected insulation readings in meg-ohms per foot at 60 degrees F is available from the engineer.
- E. All feeder insulation resistance measurements shall be forwarded to the engineer for review prior to energizing of the feeder. Copies shall also be collected into a binder and submitted to the owner as part of the operations and maintenance (O & M) documentation.
- F. Cables with an insulation resistance measurement corrected to 60 degrees F, which is less than 2 meg-ohms per foot shall be replaced by the electrical contractor at no additional cost to the owner.

END OF SECTION 16120

SECTION 16160 - PANELBOARDS

PART ONE - GENERAL:

1.01. Description of Work

- A. Where shown on the plans, indicated in the riser diagram, or listed in the panelboard schedule, furnish and install power, distribution, and lighting panels of the size and type indicated.

1.02. Submittal Requirements

- A. Where indicated on the plans, manufacture shall furnish a selective coordination report with the product submittal. This report shall include all of the time current curves for all of the overcurrent devices in the indicated system.

1.03. Basis of Design

- A. The overcurrent protection system basis of design is GE. Any changes necessary to achieve selective coordination of other approved manufacturer's equipment shall be the sole responsibility of the electrical contractor.

PART TWO - PRODUCTS:

2.01. Manufacturers

- A. Panelboards shall be manufactured by General Electric, Square D, Siemens, Cutler Hammer, or prior approved equal.

2.02. Materials and Components

- A. Distribution and power panelboards shall be of the dead-front safety type, equipped with thermal-magnetic circuit-breaker branches of sizes and types noted on the Drawings or indicated in the panelboard schedule. Breakers shall provide instantaneous trip on short circuits and time-delay trip on overloads. Main busbars shall be equipped with solderless lugs and all spaces shall be bussed. Panelboard assembly shall be enclosed in a code - gauge steel cabinet with ample wiring gutters on top, sides, and bottom. Cabinet doors shall be equipped with spring latches with locks and shall be keyed alike.
- B. Lighting panelboards shall be of the circuit breaker type of sizes listed in the panelboard schedule or noted on the Drawings. The panels shall have mains only with solderless lugs on the main busbars. Branches shall have circuit breakers of the sizes indicated on the panel schedule. Cabinets shall be of the code - gauge steel with ample wiring gutters for all wires and connections. Doors shall be the single type with spring latches with locks and all keyed alike.
- C. Unless otherwise indicated on the drawings, all panelboards shall have a fully rated symmetrical short circuit fault current rating of at least 22,000 amperes. Series rated panels are not acceptable.
- D. All panelboards shall have bolt on breakers. Plug in breakers are not acceptable.

- E. Circuit breakers shall be 20-amp, 1 pole unless indicated otherwise.
- F. Panels shall be 17" minimum width.
- G. Surface Mounted panels which are noted elsewhere in these contract documents to have TVSS/SPD protection shall have TVSS/SPD units mounted adjacent to the panels. See the details and other specifications for more details.
- H. Flush mounted panels which are noted elsewhere in these contract documents to have TVSS/SPD protection shall have integral units with Performance characteristics as close as possible to the external units. Integral TVSS/SPD units shall be furnished by the panelboard manufacturer.

PART THREE - EXECUTION:

3.01. Installation

- A. From each flush mounted panelboard, stub a minimum of five one inch empty conduits into area above ceiling.
- B. Install in each panelboard a plastic-covered typewritten circuit directory in metal frame. Indicate name, address and service telephone number of installer. Directory shall list the load served and the location of the load for each breaker. Directory shall indicate the final room numbers designated by the owner and not necessary those shown by the architect on the floor plans.
- C. All multiwire branch circuits shall have a handle tie supplied by the panel board manufacture installed to simultaneously open all ungrounded conductors. The electrical contractor may substitute multi pole breakers for this purpose at his discretion. All conductors that comprise the multiwire branch circuit shall be bundled and tye-wrapped together at the point where they enter the panel.
- D. Electrical contractor shall furnish and install leak protection pans under all non-electrical system piping which passes over electrical panels and pitch pan to drain away from electrical equipment.
- E. The electrical contractor shall apply warning label which states "Warning arc flash hazard appropriate PPE required". The warning label design shall comply with ANSI Z535.4
- F. Except where existing panels are being replaced, conductors shall not be spliced within a panel or pass through a panel. Conductors shall be neatly routed within the panel and excess wiring shall be removed.

3.02 NAMEPLATES:

- A. On all panelboards, provide engraved phenolic plastic nameplates. Unless otherwise noted, nameplates to be 1/16" thick plastic with 1/4" high white letters on black background. Hand lettering, typing under tape, embossed letters on plastic, etc., will not be acceptable.

- B. Attach nameplates with two rivets.
- C. Label shall indicate, panel name, supplying panel or transformer, voltage and phasing similar to:

PANEL PA1
120/208 VOLTS / 3 PHASE
SUPPLIED FROM 45 KVA
TRANSFORMER T1

END OF SECTION 16160

SECTION 16161 - FUSES

PART ONE - GENERAL:

1.01 MATERIALS AND COMPONENTS:

- A. Fuses shall be listed and meet UL and/or NEMA Standards for Class K5, J, L, and RKI fuses, or as indicated on the drawings.
- B. Where fuses are required elsewhere in the specifications or on the drawings for individual motor circuit protection, for motor control centers, and for motor starters, these fuses shall be class K5 fuses unless otherwise indicated. Class K5 fuses shall be dual element cartridge design with high interrupting capacity, current limiting effect, 200,000 ampere RMS symmetrical at rated voltage minimum, and a minimum time delay of ten (10) seconds at five hundred percent (500%) load.
- C. Class J and L fuses shall be provided as indicated on the Drawings for protection of non-motor loads.
- D. Fuse voltage rating shall be 250 volts for 120/208 volt system and 480 or 600 volts for 277/480 volt system.

1.02 SPARE FUSE CABINET

- A. All spare fuses shall be stored in their original cartons in a spare fuse cabinet furnished and installed by the electrical contractor. The cabinet shall be steel, surface mounted, with a hinged door, phenolic "Spare Fuse" label, flush lock, finished with gray baked enamel, and sized as required to house all spare fuses. A directory listing type and location of each fuse shall be mounted on the inside of the door. Spare fuse cabinet shall be similar to BUSSMAN Cat. No. SFC.
- B. The spare fuse cabinet shall be wall mounted within sight of the main service panel or switchboard.

PART TWO - PRODUCTS:

2.01 FUSES:

- A. Fuses shall be as manufactured by BUSSMAN or GOULD SHAWMUT.
- B. Fuses over 600 amps up to 6,000 amps shall be UL Class 'L' time-delay fuses equal to BUSSMAN "HI-CAP" KRP-C. The fuses shall hold five hundred percent (500%) of rated current for a minimum of four (4) seconds and clear twenty (20) times rated current in 0.01 seconds or less.
- C. Fuses up to 600 amps used for service entrance equipment shall be UL Class RKI dual-element fuses equal to BUSSMAN "LOW-PEAK" LPN-RK for 250 volts or LPS-RK for 600 volts. The fuses shall hold five hundred percent (500%) of rated current for a minimum of ten

(10) seconds.

- D. Fuses protecting other than service entrance equipment rated over 100 amps up to 600 amps shall be UL Class K5 dual-element fuses equal to BUSSMAN "FUSETRON" FRN-R for 250 volts or FRS-R for 600 volts unless otherwise noted on the Drawings.
- E. Fuses 100 amps and under shall be UL Class K5 dual-element fuses equal to BUSSMAN "FUSETRON" FRN-R for 250 volts or FREER for 600 volts unless otherwise noted on the Drawings.

PART THREE - EXECUTION:

3.01 FUSES:

- A. The electrical contractor shall furnish and install fuses for all switches, switchboards, distribution panel, or any other electrical equipment furnished under this division of these specifications requiring fuses.
- B. The electrical contractor shall furnish one additional set of each type and rating of fuse as spare as well as any required puller or installation devices. These shall be installed in the original boxes in the spare fuse cabinet.
- C. The electrical contractor shall provide a chart listing fuse ampacity, type and manufacturer's part number installed in each disconnect. A copy shall of this chart shall be collected into a binder and submitted to the owner as part of the operations and maintenance (O & M) documentation.

END OF SECTION 16161

SECTION 16170 - MOTOR AND CIRCUIT DISCONNECTS

PART ONE - GENERAL:

- 1.01 Furnish and install heavy-duty disconnect switches at locations shown on Drawings, and in accordance with NEC requirements. Operating mechanisms shall be the quick-make, quick-break type, with arc-suppressing characteristics. Enclosures shall be NEMA Type 1 indoors and NEMA Type 3R in outdoor and wet locations; equipped with cover interlock and provisions for padlocking operating handle in "ON" and "OFF" position.
- 1.02 Fuses shall be Gould Shawmut or Bussmann. Spare fuse cabinet shall be wall mounted with shelves suitable size to store spare fuses and fuse pullers specified. One additional set of each type/rating of fuse shall be included as spare.

PART TWO - PRODUCTS:

- 2.01 Safety switches shall be by the same manufacturer as panelboards.

PART THREE – EXECUTION

3.02 NAMEPLATES:

- A. On all disconnects, provide engraved phenolic plastic nameplates. Unless otherwise noted, nameplates to be 1/16" thick plastic with 1/4" high white letters on black background. Hand lettering, typing under tape, embossed letters on plastic, etc., will not be acceptable.
- B. Attach nameplates with two rivets.
- C. Label shall indicate, load served, supplying panel and breaker, voltage and phasing similar to:

AHU #1A
120/208 VOLTS / 3 PHASE
SUPPLIED FROM
PANEL PA1 CIRCUIT 32

END OF SECTION 16170