

SECTION 15990 - TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 RELATED WORK

- A. Extent of testing, adjusting, and balancing work required by this section is indicated by requirements of this section; and is defined to include, but is not necessarily limited to, air distribution systems, hydronic distribution systems and associated equipment, and apparatus of mechanical work. The work consists of setting speed and volume (flow) adjusting facilities provided for systems, recording data, conducting tests, preparing and submitting reports, and recommending modifications to the work as required by the contract documents.
- B. Testing, adjusting, and balancing specified in this section include, but are not limited to, the following mechanical equipment:
 - 1. Fans.
 - 2. Ductwork systems, including terminal units.
 - 3. Pumps.
 - 4. Pool heaters.
 - 5. Rooftop units.
 - 6. Domestic hot water recirculating pumps & system balancing valves shown on plumbing plans.

1.3 QUALITY ASSURANCE

- A. Contractor's Qualifications: Firm with at least 5-years of successful testing, adjusting, and balancing experience on projects with testing and balancing requirements similar to those required for this project.

1.4 QUALIFICATIONS OF CONTRACTOR

- A. The Mechanical Contractor shall procure the services of a testing and balancing agency specializing in the testing, adjusting and balancing of environmental systems to perform the above mentioned work. Testing and balancing report shall be certified by a Registered Professional Engineer, or a NEBB or TABB Certified Balancing Supervisor who is registered and/or certified in the jurisdiction where the testing is being conducted. The Engineer, NEBB, or TABB Supervisor shall represent the balancing firm in progress meetings as required, and shall be available for interpreting all material found in the balance report. Any individual involved in actual testing and balancing shall be under the direct supervision of the Registered Professional Engineer or the NEBB or TABB certified supervisor.
- B. Codes and Standards:
 - 1. NEBB Compliance: Comply with NEBB's latest edition of "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.

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2. TABB Compliance: Comply with TABB's "Testing, Adjusting and Balancing Bureau Standards, Procedure and Specifications" as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.
3. AABC Compliance: Comply with the latest edition of AABC's Manual MN-1 "AABC National Standards", as applicable to mechanical air and hydronic distribution systems, and associated equipment and apparatus.

1.5 APPROVAL OF CONTRACTOR

- A. Any Testing, Adjusting and Balancing (TAB) firm desiring to offer their services for this work shall submit their qualifications to the Engineer, not less than seven (7) calendar days before the bid date. Their submittals shall include the name and Professional Engineer stamp of the engineer who will be supervising the testing and balancing. Copies of each Supervisor's certificate shall be included in the submittals. This submittal of qualifications will be reviewed by the Engineer. The Engineer will then approve or disapprove this TAB firm based on these qualifications.

1.6 SUBMITTALS

- A. Submit certified test reports, signed by Test and Balance Supervisor who performed TAB work. In addition, have the report certified by the Professional Engineer who is familiar with the TAB work on this project.
- B. Submit biographical data on Engineer who is to directly supervise testing, adjusting, and balancing work.

1.7 JOB CONDITIONS

- A. Do not proceed with testing, adjusting, and balancing work until work has been completed and is operable. Ensure that there is no latent residual work still to be completed.
- B. Do not proceed until work scheduled for testing, adjusting, and balancing is clean and free from debris, dirt, and discarded building materials.
- C. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation of same during each working day of testing and balancing. Preliminary TAB requirements shall be ascertained prior to the commencement of work through a review of available plans and specifications for the project. In addition, visual observations at the site during construction shall be made to determine the location of required balancing devices and that they are being installed properly for the need.
- D. Before any air balance work is done, the following will be completed on each system:
 1. Check for duct leakage.
 2. Assure filters are installed.
 3. See that filters are changed if they are dirty.
 4. Check for correct fan rotation.
 5. Check equipment vibration.
 6. Check automatic dampers for proper operation.
 7. Place all volume control dampers and outlets wide open at this time.
- E. Before any hydronic balancing work is done, the system shall be checked for plugged strainers, correct pump rotation, correct control valve installation and operation, air locks, check system static pressure to

assure system operation is below the limits of the system relief valves, proper flow meter and check valve installation. All throttling devices and control valves shall be open at this time.

1.8 INSPECTION OF THE CONTRACT DOCUMENTS

- A. The Test and Balance contractor shall request from the Division 15 contractor a set of documents so that he can review his ability to balance the mechanical system. If any portion of the system cannot be balanced due to its configuration, a report shall be issued to the Division 15 contractor pointing out those areas where proper balancing will be impossible to achieve. This report shall be issued in time to make corrective actions prior to the purchase of materials.

PART 2 - PRODUCTS

2.1 PATCHING MATERIALS

- A. Except as otherwise indicated, use the same products as used by the original Installer for patching holes in insulation, ductwork and housings, which have been cut or drilled for test purposes, including access for test instruments, attaching jigs, and similar purposes.
 - 1. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.2 TEST INSTRUMENTS

- A. Utilize test instruments and equipment for TAB work required, of type, precision, calibration and capacity as recommended in the following TAB standards:
 - 1. NEBB's Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
 - 2. TABB's Standards, Procedures and Specifications.
 - 3. AABC's Manual MN-1 "AABC National Standards".

PART 3 - EXECUTION

3.1 GENERAL

- A. Examine installed work and conditions under which testing is to be done to ensure that work has been completed, cleaned, and is operable. Do not proceed with TAB work until unsatisfactory conditions have been corrected in manner acceptable to Tester.
- B. Test, adjust and balance environmental systems and components, as indicated, in accordance with procedures outlined in applicable standards.
- C. Test, adjust and balance system during summer season for air conditioning systems and during winter season for heating systems, including at least period of operation at outside conditions within 5°F wet bulb temperature of maximum summer design condition, and within 10°F dry bulb temperature of minimum winter design condition. When seasonal operation does not permit measuring final temperatures, then take final temperature readings when seasonal operation does permit.

- D. Balance all flows to terminals within +10% to -5% of design flow quantities. Measure and record the following data.
- E. Systems may be tested in increments when approved by the Engineer.
- F. When testing and balancing involve the building temperature control systems, coordinate with the temperature control subcontractor to achieve the desired results. All setpoints shall be documented and included with test report.
- G. When deemed necessary by the mechanical consulting Engineer, the Test & Balance firm shall run temperature and/or humidity recordings and shall read any of the air or water report quantities in the presence of the engineer for verification purposes.
- H. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time.
- I. The contractor shall report observations made on the job such as noisy systems and unusual equipment vibration.

3.2 AIR BALANCE

- A. Air supply, return and exhaust systems with air quantities for each air device; air handling units including supply, return, mixed, and outside temperatures and fan data including CFM, static pressure, fan RPM, motor running and full load amperage before and after final balance. Air diffusion patterns shall be set to minimize objectional drafts and noise.
- B. The supply, return and exhaust fan static pressure shall be set by the balancing firm and the control contractor if the systems have fan volume control dampers. The duct static shall be confirmed both through the instrumentation installed on the job and by the balancing contractor. Fan air flows shall be confirmed by duct pitot traverse. The system shall be tested in all operation modes (full return air, full outside air, modulated damper position, full cooling). Amperages shall be checked in all modes. The fan speed resulting in satisfactory system performance shall be determined at full design delivery. Inlet or outlet fan volume control dampers shall be in the wide open position and one path presenting the greatest resistance to flow shall be fully open and unobstructed.
- C. Verify operation of each room thermostat/sensor serving VAV terminal units over full range of heating and cooling to ensure proper sequence of control of the VAV operator and reheat coil valve. Field verify minimum and maximum air quantities of all variable volume terminal units and record final settings.
- D. Final adjustments shall include, but are not limited to, the following:
 - 1. All Fans: Belt Drive
 - a. RPM. Include sheave and belt exchange to deliver air flow within limits of installed motor horsepower and mechanical stress limits of the fan. Determine the limiting fan tip speed before increasing RPM. Final fan speed setting shall allow for predicted filter loading and shall establish proper duct pressures for operation of zone CFM regulators.
 - 2. All Fans: Direct Drive
 - a. RPM with speed taps. Set fan speed on tap which most closely approaches design CFM. Report tap setting on equipment data sheet as high, medium or low.

- b. RPM with speed control rheostat. Set output of fan at design CFM by adjusting the SCR or potentiometer. After adjustment, check fans ability to restart after powering down. Increase setting if required for proper starting. Mark setting on the adjustment device.
 - 3. Motor Starter
 - a. Mechanical Contractor Furnished
 - 4. Thermal Heaters
 - a. Magnetic and Manual Starters. Furnish and exchange thermals as required for proper motor protection.
 - E. All major equipment performance tests shall be verified after system has been balanced and proper airflow rates established.
 - F. Patch holes in insulation, ductwork, and housings, which have been cut or drilled for test purposes, in manner recommended by original Installer. Report all damage requiring repair to the Division 15 contractor.
- 3.3 HYDRONIC BALANCE
- A. Start hydronic balance after piping system has been cleaned, including strainers, and controls are functioning as required under other sections of Division 15.
 - B. Where liquid flow balancing cannot be accomplished due to system deficiencies such as excessive or lack of pumping head, inadequately sized motors, pressure drops not determinable or similar problems, prepare a list of such deficiencies and the suggested system modifications and furnish to the Engineer in writing and prior to submission of test report for necessary action.
 - C. Hydronic Balance shall include, but not be limited to the following:
 - 1. Pool heater inlet and leaving water temperatures, reset supply temperature (if applicable), gas flow rate and flue gas analysis.
 - 2. All circulating pump flow rates, pressures, running amperage, and full load amperage at design flow and shut-off conditions.
- 3.4 ELECTRIC HEAT
- A. Full load amperage of all electric heating elements.
- 3.5 DOMESTIC HOT WATER RECIRCULATION
- A. Balance hot water recirculation pumps and all system balancing valves shown on plumbing drawings.
- 3.6 REPORT OF WORK
- A. Submit six (6) bound copies (or as required in Division 1) of the final testing and balancing report at least 15 days prior to the Mechanical Contractor's request for final inspection. All data shall be recorded on applicable reporting forms. The report shall include all operating data as listed in sections above, a list of all equipment used in the testing and balancing work, and shall be signed by the supervising engineer and

affixed with his certification seal. Final acceptance of this project will not take place until a satisfactory report is received.

- B. The pitot tube traverse method for determining CFM shall be used and recorded wherever possible.
- C. Hydronic systems with meters: The system shall be balanced proportionally using the flow meters. On completion of the balance, the following information shall be recorded in the report: flow meter size and brand, required flow rate and pressure drop, valve settings on meters with a readable scale, flow rate in both full coil flow and full bypass modes.
- D. Hydronic systems without meters (thermal or terminal rated pressure drop balance): the system shall be balanced proportionally to the terminal ratings. On completion of the balance the following information shall be recorded in the report: design entering and leaving water temperature/pressure drop, final balance entering and leaving water temperature/pressure drop.
- E. When all hydronic balancing is done, all valves shall be marked or the locking rings set. Control valve bypass loops shall be set with the balancing valve to provide equal flow in either mode. Confirm in writing.
- F. After all balancing is complete and all coordination with the contractor and the engineer is complete, furnish a bound report which shall contain the following information:
 - 1. RPM, drive sheave information (as installed and as changed), fan nameplate information, motor nameplate information, and amperage and voltage to all motors (in all operating modes).
 - 2. Static pressure across all components of the system.
 - 3. Original design and final balanced CFM at each system terminal. Include the terminal size, reading orifice size, and velocities read to attain the CFM.
 - 4. Pump and motor nameplate information, amperage and voltage to all motors, pressure drop across all system terminals, pressure rise across the pump in PSI and feet of head.
 - 5. Thermal protection for all motors shall be recorded. Starter brand, model, enclosure type, installed thermal heaters and the rating of the heaters, required thermal heaters and the rating of the heaters if different than installed shall be recorded. If the starters were furnished by the mechanical contractor, the heaters shall be changed to the correct size and so noted in the report. If the starters were furnished by the electrical contractor, the correct heater sizes shall be noted in the report and the electrical contractor shall be advised.
 - 6. The report shall include a sheet which shall report the method of balance, project altitude, and any correction factors used in the calculations.

3.7 GUARANTEE OF WORK

- A. Guarantee the tests and balance for a period of 90 days from date of final acceptance of the test and balance report. During this period, the TAB Contractor shall make personnel available at no cost to the Owner to correct deficiencies in the balance or to help troubleshoot problem areas.

3.8 ADDITIONAL INSTRUCTIONS

- A. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings at completion of TAB work. Provide markings with paint or other suitable permanent identification materials.
- B. Prepare report of recommendations for correcting unsatisfactory mechanical performances when system cannot be successfully balanced; including, where necessary, modifications which exceed requirements of contract documents for mechanical work.

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- C. Retest, adjust, and balance systems subsequent to significant system modifications, and resubmit test results.

3.9 RETAINAGE

- A. Contract payment retainage will be withheld against the Mechanical Contractor until the final completion of this section of work has been demonstrated by the submission of the TAB report and an evaluation of its contents has been made by the Engineer.

END OF SECTION 15990

SECTION 16010 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 EXECUTION OF THE WORK

- A. These specifications call out certain duties of the Contractor and his Subcontractors. They are not intended as a material list of items required by the Contract.
- B. This division of the specification covers the electrical systems of the project. It includes work performed by the electrical trades as well as trades not normally considered as electrical trades.
- C. Provide all items and work indicated on the Drawings and all items and work called for in this division of the specification in accordance with the conditions of Division One - General Requirements, of the Contract Documents. This includes all incidentals, equipment, appliances, services, hoisting, scaffolding, supports, tools, supervision, labor, consumable items, fees, licenses, etc., necessary to provide complete systems. Perform start-up and checkout on each item and system to provide fully operable systems.
- D. Comply with all provisions of the Contract Documents including Division 1, General Conditions, and Supplementary General Conditions of the specifications.
- E. Certain terms such as "shall, provide, install, complete, start up" are not used in some parts of these specifications. This does not indicate that the items shall be less than completely installed or that systems shall be less than complete.
- F. Examine and compare the Electrical Drawings and Specifications with the Drawings and Specifications of other trades, and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid the most stringent requirements must be included in said bid. Install and coordinate the electrical work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor, caused by his neglect to do so, to be made by him at this own expense.
- G. It is the intent of the Drawings and Specifications to provide a complete workable system ready for the Owner's operation. Any item not specifically shown on the Drawings or called for in the Specifications, but normally required to conform with the intent, are to be considered a part of the Contract.
- H. These Specifications are basically equipment and performance Specifications. Actual installations shall be as shown on the Drawings. Installations and details shown on the Drawings shall govern where these differ from the Specifications.
- I. All products and materials furnished by the Contractor shall be new, clean, unused (temporary lighting and power products are excluded), free from defects, and free from damage and corrosion. All materials used shall bear the Underwriters' Laboratory, Inc. label provided a standard has been established for the material in question.
- J. No exclusion from, or limitation in, the symbolism used on the Drawings for electrical work or the languages used in the Specifications for electrical work shall be interpreted as a reason for omitting the accessories necessary to complete any required system or item of equipment.

- K. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.
- L. Except for conduit, conduit fittings, outlet boxes, wire and cable, all items of equipment or material shall be the product of one manufacturer throughout. Multiple manufacturers will not be permitted.

1.2 COORDINATION OF THE WORK

- A. Certain materials will be provided by other trades. Examine the Contract Documents to ascertain these requirements.
- B. Carefully check space requirements with other trades and the physical confines of the area to insure that all material can be installed in the spaces allotted thereto including finished suspended ceilings. Make modifications thereto as required and approved.
- C. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.
- D. Wherever work interconnects with work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.
- E. Consult with other trades regarding equipment so that motor controls are of the same manufacturer.
- F. Due to the type of the installation, a fixed sequence of operation is required to properly install the complete system. Coordinate, project and schedule work with other trades in accordance with the construction sequence.
- G. The locations of lighting fixtures, outlets, panels and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.
- H. Exercise particular caution with reference to the location of panels, outlets, switches, etc., and have precise and definite locations approved by the Architect/Engineer before proceeding with the installation.
- I. The Drawings show only the general run of raceways and approximate location of outlets. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Architect/Engineer and receive his approval before such alterations are made. All such modifications shall be made without additional cost to the Owner.
- J. Obtain from the Architect/Engineer in the field the location of such outlets or equipment not definitely located on the Drawings.
- K. Circuit "tags" in the form of arrows are used where shown to indicate the home runs of raceways to electrical distribution points. These tags show the circuits in each home run and the panel designation. Show the actual circuit numbers on the finished record tracing and on panel directory card. Where circuiting is not indicated, Electrical Subcontractor must provide required circuiting in accordance with the loading indicated on the drawings and/or as directed.

- L. The Drawings generally do not indicate the exact number wires in each conduit for the branch circuit wiring of fixtures, and outlets, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and/or circuit numbers indicated and control wiring diagrams, if any, specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC.
- M. Adjust location of conduits, panels, equipment, pull boxes, fixtures, etc. to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each raceway prior to fabrication.
 - 1. Right of Way: Lines which pitch have the right-of-way over those which do not pitch. For example: steam, condensate, and plumbing drains normally have right-of-way. Lines whose elevations cannot be changed have right-of-way over lines whose elevations can be changed.
 - 2. Make offsets, transitions and changes in direction to raceways and bus duct and as required to maintain proper head room in pitch of sloping lines whether or not indicated on the Drawings.
- N. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings or on color-coded AutoCad drawing. With these layouts, coordinate the work with the work of other trades. Such detailed work to be clearly identified on the Drawings as to the area to which it applies. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.
- O. Contractor shall furnish services of an experienced superintendent, who shall be in constant charge of all work, and who shall coordinate his work with the work of other trades. No work shall be installed before coordinating with other trades.
- P. Requests for Information (RFIs): The Contractor shall be responsible for complete review and understanding of the Contract Documents. RFIs shall not be used to locate information for the Contractor. The Engineer will not respond to requests where such information is available from a careful study and comparison of the Contract Documents, field conditions, or prior project correspondence or documentation.

1.3 EXAMINATION OF SITE

- A. Prior to the submitting of bids, the Contractor shall visit the site of the job and shall familiarize himself with all conditions affecting the proposed installation and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph will in no way relieve the contractor of performing all necessary work shown on the Drawings.

1.4 PROGRESS OF WORK

- A. The Contractor shall order the progress of his work so as to conform to the progress of the work of other trades and shall complete the entire installation as soon as the conditions of the building will permit. Any cost resulting from the defective or ill-timed work performed under this section shall be borne by the Contractor.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Ship and store all products and materials in a manner which will protect them from damage, weather and entry of debris. If items are damaged, do not install, but take immediate steps to obtain

replacements or repair. Any such repairs shall be subject to review and acceptance of the Architect/Engineer.

- B. Delivery of Materials: Deliver materials (except bulk materials) in manufacturer's unopened container fully identified with manufacturer's name, trade name, type, class, grade, size and color.
- C. Storage of Materials, Equipment and Fixtures: Store materials suitably sheltered from the elements, but readily accessible for inspection by the Architect/Engineer until installed. Store all items subject to moisture damage in dry, heated spaces.

1.6 EQUIPMENT ACCESSORIES

- A. Establish sizes and location of the various concrete bases required. Coordinate with General Contractor and provide all necessary anchor bolts together with templates for holding these bolts in position.
- B. Provide supports, hangers and auxiliary structural members required for support of the work.
- C. Furnish and set all sleeves for passage of raceways through structural, masonry and concrete walls and floors and elsewhere as will be required for the proper protection of each raceway and bus duct passing through building surfaces.
- D. Wall mounted equipment may be directly secured to wall by means of steel bolts. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Globe-Strut and Unistrut, may be used for mounting arrays of equipment.

1.7 EXCAVATION AND TRENCHING

- A. Provide excavation for the work. Excavate all material encountered, to the depths indicated on the Drawings or required. Remove from the site excavated materials not required or suitable for backfill. Provide grading as may be necessary to prevent surface water from flowing into trenches or other excavations. Remove any water accumulating therein. Provide sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel.
- B. Provide trenches of widths necessary for the proper execution of the work. Grade bottom of the trenches accurately to provide uniform bearing and support the work on undisturbed soil at every point along its entire length. Except where rock is encountered, do not excavate below the depths indicated. Where rock excavations are required, excavate rock to a minimum overdepth of four inches below the trench depths indicated on the Drawings or required. Backfill overdepths in the rock excavation and unauthorized overdepths with loose, granular, moist earth, thoroughly machine tamped to a compaction level as specified by the Architect. Whenever unstable soil that is incapable of properly supporting the work, as determined by the Architect/Engineer, is encountered in the bottom of the trench, remove soil to a depth required and backfill the trench to the proper grade with coarse sand, fine gravel or other suitable material.
- C. Excavate trenches for utilities to a depth that will provide the following minimum depths to cover from existing grade or from indicated finished grade, whichever is lower, unless otherwise specifically shown.
 - 1. Primary electric service: 4 feet (minimum)
 - 2. Secondary electric service: 2 feet (minimum)

3. Telephone service: 2 feet (minimum).

1.8 BACKFILLING OF TRENCHES

- A. Do not backfill trenches until all required tests have been performed and the installation observed by the Engineer. Comply with the requirements of other sections of these specifications. Deposit in 6 inch layers and thoroughly and carefully tamp until the work has a cover of not less than 1 foot. Backfill and tamp remainder of trench at 12 inch intervals until complete. Uniformly grade the finished surface.

1.9 CUTTING, PATCHING, ETC.

- A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of raceway, outlets or other equipment, the work shall be carefully done. Any damage to the building, piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.
- B. The Contractor shall do no cutting, channeling, chasing or drilling of unfinished masonry, tile, etc., unless he first obtains permission from the Architect/Engineer. If permission is granted, the Contractor shall perform this work in a manner approved by the Architect/Engineer.
- C. Where conduits, outlet, junction or pull boxes are mounted on a painted surface, or a surface to be painted, they shall be painted to match the surface. Wherever support channels are cut, the bare metal shall be cold galvanized.
- D. Slots, chases, openings and recesses through floors, walls, ceilings, and roofs will be provided by the various trades in their respective materials. The trade requiring them to properly locate such openings shall be responsible for any cutting and patching caused by the neglect to do so.

1.10 NOMINAL MOUNTING HEIGHTS (UNLESS OTHERWISE NOTED)

- A. Unless otherwise noted or required because of special conditions, locate outlets as follows:
1. Heights listed are from finished floor to center of device. Verify exact locations with the Architect/Engineer before installation.
 - a. Convenience and signal outlets: 18 inches unless otherwise noted.
 - b. Lighting Switches: 48 inches
 - c. Disconnect Switches and Motor Controllers: 60 inches
 - d. Wall Telephone Outlets: 54 inches
 - e. Above counter convenience outlets: 42 inches
 - f. Strobes: No less than 80" and no greater than 96", and to be consistent throughout building.
 - g. Horn/Strobes: No less than 80" and no greater than 96", and to be consistent throughout building.

- h. Mini-Horns: No less than 80" and no greater than 96", and to be consistent throughout building.
- i. Card key access reader: 48 inches
- j. Fire alarm pull station: 48 inches
- k. Disposal switch: 42 inches
- l. Light fixtures: Refer to luminaire schedule on drawings.

1.11 CLEANING UP

- A. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of his work. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean, subject to the Architect/Engineer's instructions, which shall be promptly carried out.
- B. Contractor shall clean all fixtures and equipment at the completion of the project.
- C. All switchboards, panelboards, wireways, trench ducts, cabinets, enclosures, etc shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project. Equipment shall be opened for observation by the Architect/Engineer as required.

1.13 FIRESTOPPING

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

1.14 WATERPROOFING

- A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Architect/Engineer and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.
- B. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface at his own expense and as directed by the Architect/Engineer.

1.15 SUPPORTS

- A. Support work in accordance with the best industry practice and the following.
- B. Include supporting frames and racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets.
- C. Include supporting frames or racks for equipment, intended for vertical mounting, which is required in a free standing position.
- D. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members. They shall be rigidly bolted or welded together and adequately braced to form a

substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them.

- E. Nothing, (including outlet, pull and junction boxes and fittings) shall depend on electric conduits, raceways, or cables for support, except that threaded hub type fittings having a gross volume not in excess of 100 cubic inches may be supported by heavy wall conduit, where the conduit in turn is securely supported from the structure within five inches of the fittings on two opposite sides.
- F. Nothing shall rest on, or depend for support on, suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling).
- G. Provide required supports and hangers for conduit, equipment, etc., so that loading will not exceed allowable loadings of structure.

1.16 FASTENINGS

- A. Fasten electrical equipment and devices to building structure in accordance with the best industry practice and the following.
- B. As a minimum procedure, where weight applied to the attachment points is 100 pounds or less, fasten to building elements of:
 - 1. Wood - with wood screws.
 - 2. Concrete and solid masonry - with bolts and expansion shields.
 - 3. Hollow construction - with toggle bolts.
 - 4. Solid metal - with machine screws in tapped holes or with welded studs.
 - 5. Steel decking or subfloor - with fastenings as specified below for applied weights in excess of 100 pounds.
- C. As a minimum procedure, where weight applied to building attachment points exceeds 100 pounds, but is 300 pounds or less, conform to the following:
 - 1. At concrete slabs utilize 24" x 24" x 1/2" steel fishplates on top with through bolts. Fishplate assemblies shall be chased in and routed flush with the top of slab screed line, where no fill is to be applied.
 - 2. At steel decking or subfloor for all fastenings, utilize through bolts or threaded rods. The tops of bolts and rods shall be set at least one inch below the top fill screed line and routed in. Suitable washers shall be used under bolt heads or nuts. In cases where the decking or subfloor manufacturer produces specialty hangers to work with his decking or subfloor such hangers shall be utilized.
- D. Where weight applied to building attachment points exceeds 300 pounds, coordinate with and obtain approval of Architect and conform to the following:
 - 1. Utilize suitable auxiliary channel or angle iron bridging between building structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Utilize threaded rods or bolts to attach to bridging members.

- E. Floor mounted equipment shall not be held in place solely by its own dead weight. Include floor anchor fastenings in all cases.
- F. For items which are shown as being ceiling mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging tying to the building structural elements.

PART 2 - PRODUCTS

- 2.1 If products and materials are specified or indicated on the Drawings for a specific item or system, use those products or materials. If products and materials are not listed in either of the above, use first class products and materials, subject to approval of Shop Drawings where Shop Drawings are required or as approved in writing where Shop Drawings are not required.
- 2.2 All equipment capacities, etc., are listed for job site operating conditions. All equipment sensitive to altitudes or ambient temperatures to be derated and method of derating shown on Shop Drawings. Where operating conditions shown differ from the laboratory test conditions, the equipment to be derated and the method of derating shown on Shop Drawings.

PART 3 - EXECUTION

- 3.1 Follow manufacturer's instructions for installing, connecting and adjusting all equipment. Provide one copy of such instructions to the Architect/Engineer before installing any equipment. Provide a copy of such instructions at the equipment during any work on the equipment. Provide all special supports, connections, wiring, accessories, etc.
- 3.2 Use mechanics skilled in their trade for all work.
- 3.3 Keep all items protected before and after installation. Clean up all debris.
- 3.4 Perform all tests required by local authorities in addition to tests specified herein, such as life safety systems.
- 3.5 Applicable equipment and materials to be listed by Underwriters' Laboratories and Manufactured in accordance with ASME, NEMA, ANSI or IEEE standards and as approved by local authorities having jurisdiction.
- 3.6 Before commencing work, examine all adjoining, underlying, etc., work on which this work is in any way dependent for perfect workmanship and report any condition which prevents performance of first class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

END OF SECTION 16010

SECTION 16020 - WORK INCLUDED

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide the work included in accordance with the Contract Documents.
- B. Provide all labor, materials, equipment, tools, appliances, auxiliaries, services, hoisting, scaffolding, support, supervision, and Project Record Documents, and perform all operations for the furnishing and installing of the complete electrical system, including but not limited to the work described hereinafter. The work shall meet or exceed the latest codes, regulations and requirements of The State of New Mexico.
- C. The electrical work is shown schematically on the Drawings to indicate the general system arrangement and configuration. The work of this Division shall include coordination with the work of other Divisions of the Specifications and the Contract Documents so as to provide a complete and operational system capable of being readily operated and maintained, including approved re-arrangement of the systems and equipment and re-routing of distribution services to enable the complete system to fit within the confines of the allotted electrical spaces, all to the satisfaction of the Architect/Engineer or as directed by the Architect/Engineer.
- D. The work includes, but is not limited to the following:
 - 1. Equipment supports and miscellaneous steel for electrical equipment.
 - 2. Vibration isolation for the electrical installation.
 - 3. Temporary power and lighting system.
 - 4. Exterior and site lighting.
 - 5. Distribution feeders.
 - 6. Complete 277/480 volt and 120/208 volt lighting and power distribution system, including emergency system.
 - 7. Telecommunications distribution systems.
 - 8. Lighting fixtures, lamps, convenience outlet systems, and miscellaneous wiring devices.
 - 9. Motor power wiring.
 - 10. Miscellaneous electrical equipment and system, unless otherwise noted.
 - 11. Balancing loads.
 - 12. Water Feature connections and water feature lighting.
 - 13. Grounding system.
 - 14. Mechanical system connections.
 - 15. Sealing of sleeves and other electrical openings.

16. Electrical heaters: baseboard, cabinet and unit types.
17. Lighting control system.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 16020

SECTION 16025 - CODES AND FEES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Comply with Codes in accordance with the Contract Documents.

1.2 CODES

- A. The electrical installation shall be in compliance with the requirements of The state of New Mexico, OSHA, NEC and the rules, regulations and requirements of the power company supplying power to the buildings.
- B. The electrical installation and the Contractor shall comply fully with all city, county and state laws, ordinances and regulations applicable to electrical installations.
- C. All equipment shall be equal to or exceed the minimum requirements of NEMA, and IEEE, and UL.
- D. Should any change in Drawings or specifications be required to comply with governmental regulations, the Contractor shall notify Architect/Engineer prior to execution of the work. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Architect/Engineer and at no additional cost to the Owner.

1.3 FEES

- A. All local fees and permits and services of inspection authorities shall be obtained and paid for by the Contractor. The Contractor shall cooperate fully with local utility companies with respect to their services. Contractor shall include in his bid, any costs to be incurred relative to power service (primary and/or secondary) and telephone service.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 16025

SECTION 16030 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide Project Record Documents of Electrical Work in accordance with the Contract Documents.
- B. During construction keep an accurate record of all deviations between the work as shown on Drawings and that which is actually installed. Keep this record set of prints at job site for review by the Architect/Engineer.
- C. Upon completion of the installation, obtain from the Architect a complete set of drawings or electronic drawing files. Enter therein, in a neat and accurate manner, a complete record of all revisions to the original Drawings as actually installed. The cost for drawings and for making required changes shall be borne by this Contractor. Submit one (1) set of revised drawings to the Architect/Engineer for review. After review by the Architect/Engineer for transmittal to the Owner.
- D. Provide typed as-built panel schedules upon completion of the work.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

- 3.1 Provide in the main electrical service room a framed copy under glass of the appropriate single line riser diagram as reviewed by the Architect/Engineer. Media shall be a high quality presentation-type.

END OF SECTION 16030

SECTION 16035 - REVIEWS AND ACCEPTANCES

PART 1 - GENERAL

1.1 SUBSTITUTIONS OF MATERIALS OR EQUIPMENT

- A. Wherever the word "for approval" or "approved" are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of apparatus for that specified, submit all information pertinent to the adequacy and adaptability of the proposed apparatus and secure Architect/Engineer's acceptance before apparatus is ordered.
- B. All requests for substitution of materials or equipment shall be made by the Contractor within thirty (30) days after the execution of the Owner/Contractor Agreement. No requests for substitution will be accepted prior to execution of the Owner/Contractor agreement or from anyone other than the successful Contractor.
- C. Wherever operating results such as quantity delivered, or the like are specified, or a definite make and size of apparatus is specified, for which such quantities are readily determinable - the make and size of apparatus which is proposed must conform substantially (in regard to the operating results) to the quantities specified or implied. Same shall apply to important dimensions relating to operation of apparatus in coordination with the rest of the system, or to properly fitting it into available space conditions. Any substitution of equipment or apparatus shall include all necessary revisions, as required to complete the installation.
- D. Acceptance of substitutions for equipment specified herein will not be given merely upon submission of manufacturers' names and will be given only after receipt of complete and satisfactory performance data covering a complete range of operating conditions in tabular and graphical form. Furnish complete and satisfactory information relative to equipment dimensions, weight, etc. Acceptance of all equipment specified or shown on the Drawings, or substitutions submitted for that specified or shown on the Drawings, will be granted if such equipment, in the opinion of the Architect/Engineer, conforms to the performance requirements, space conditions, weight requirements and quality requirements. Any additional construction and design costs incurred as a result of any accepted substitution shall be borne by this Contractor. The opinion and judgment of the Architect/Engineer shall be final, conclusive and binding.

1.2 SUBMITTAL LIST

- A. Within thirty (30) days after date of execution of Owner/Contractor Agreement, submit for review and acceptance a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom this trade proposes to employ.
- B. Any requests for substitutions of equipment or materials must be submitted and returned prior to submitting the Submittal List. Only specified or accepted manufacturers or suppliers shall appear on the Submittal List.
- C. The complete Submittal List must be reviewed and accepted by the Architect/Engineer prior to submittal of shop drawings. No shop drawings will be processed without an accepted Submittal List.
- D. The Submittal List shall include all material, systems and equipment as listed herein.

1.3 SHOP DRAWINGS

- A. Prepare and submit detailed shop drawings for materials, systems and equipment as listed herein, including locations and sizes of all openings in floor decks, walls and floors.

- B. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.
- C. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and resubmitting as may be required. All submittals shall be complete and contain all required and detailed information.
- D. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve Contractors from responsibility of furnishing same of proper dimensions and weight, capabilities, sizes, quantity, quality and installation details to efficiently perform the requirements and intent of the Contract. Such acceptance shall not relieve Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.
- E. Each shop drawing shall contain job title and reference to the applicable drawing or specification article.
- F. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be returned without review.
- G. Each equipment submittal shall substantiate conformance to the specification by supplying a document indicating equipment submitted meets or exceeds each line item in the specification or exception taken. Submittals provided without this information will be returned without review.
- H. All nameplate data shall be complete at time of equipment submittals - refer to Section 16060 for identification requirements.
- I. For each room or area of the building containing switchboards, panelboards, transformers, sound systems cabinets, telephone backboards, signal system backboards, fire alarm terminal cabinets, fire alarm control panels, consoles, etc. the following is required to be submitted for review and acceptance at the time of the equipment submittal.

1. Floor Plans

Plan reviews (including sections and elevations when requested) for the equipment indicated in the exact location in which it is intended to be installed. These plans shall be of a scale not less than 1/4" = 1'-0". They shall be prepared in the following manner.

- a. Indicated the physical boundaries of the space including door swings and ceiling heights and ceiling types (as applicable).
- b. Illustrate all electrical equipment proposed to be contained therein. Include top and bottom elevations of all electrical equipment. The drawings must be prepared utilizing the dimensions contained in the individual equipment submittals.
- c. Illustrate all other equipment therein such as conduits, detectors, luminaires, ducts, registers, pullboxes, wireways, structural elements.
- d. Note the operating weight of each piece of equipment.

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- e. Note the heat release from each piece of electrical equipment in terms of BTU per hour. This information shall be that which is supplied by the respective manufacturers.
 - f. Illustrate all concrete pads, curbs, etc.
 - g. Note all code clearances from all equipment by dimensions.
 - h. Indicate maximum normal allowable operating temperature for each piece of equipment (as per each respective manufacturer's recommendation).
2. Equipment Delivery and Removal Routes
- a. Provide a set of reproducible documents indicating the methods of equipment delivery for all major pieces of equipment.
 - b. Provide in conjunction with the above, a set of reproducible documents from the then current Contract Documents indicating the methods of equipment removal for all major pieces of equipment.
 - c. Indicate on floor plans by means of arrows, the complete path for equipment delivery and removal.
 - d. Where equipment will be required to be hung temporarily from a slab or beam, note same on the submission including the weight of the equipment to be hung and the weight of the hoisting equipment.
 - e. Note all heights of conduits, ductwork, link beams, doorways, transoms, piping, etc. in the proposed delivery and removal paths assuring that adequate headroom is provided.
- J. Shop Drawing Submittals shall be provided for the applicable equipment.
- 1. Panelboards (16160)
 - 2. Disconnect Switches and Enclosed Circuit Breakers (16170)
 - 3. Fuses (16181)
 - 4. TVSS (16400 and 16401)
 - 5. Switchboards (16440)
 - 6. Dry Type Transformers (16470)
 - 7. Luminaires and Accessories (16500)
 - 8. Fire Alarm System (16721)
 - 9. Lighting Control (16930)

PART 2 -PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 16035

SECTION 16045 - MAINTENANCE MANUALS

PART 1- GENERAL

1.1 DESCRIPTION

- A. General: Provide maintenance manuals in accordance with the Contract Documents.

1.2 SUBMITTALS

- A. Provide five (5) copies of each manual.
- B. Manuals to be 8-1/2 inches x 11 inches size in hard back 3-ring loose leaf binders. Use more than one volume if required; do not overfill binders.
- C. Submit one (1) copy to Architect/Engineer. After review and acceptance assemble other copies.
- D. Manuals to be completed and in Owner's hand prior to turning building over to Owner and at least 10 days prior to instruction to operating personnel.

PART 2 -PRODUCTS

2.1 MANUFACTURER'S LITERATURE

- A. General: Provide manufacturers literature on all items of equipment and components as regularly published by the respective manufacturers for proper preventative and comprehensive maintenance.

PART 3 - EXECUTION

3.1 Provide maintenance manuals including but not limited to the following:

- A. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
- B. Operating instructions for complete system including:
1. Normal starting, operating, and shut-down.
 2. Emergency procedures for fire or failure of major equipment.
 3. Summer and winter special procedures, if any.
 4. Day and night special procedures, if any.
- C. Maintenance instruction including:
1. Proper lubricating instructions for each piece of equipment, and date when lubricated.
 2. This shall be a separate list in addition to manufacturer's data.
 3. Necessary cleaning, replacement and/or adjustment schedule.
- D. Manufacturer's data on each piece of equipment including:

1. Installation instructions.
 2. Drawings and specifications.
 3. Parts list, including recommended items to be stocked.
 4. Complete wiring diagrams.
 5. Marked or changed prints locating all concealed parts and all variations from the original system design.
 6. Test and inspection certificates.
- 3.2 Provide specific equipment data including but not limited to all materials and equipment listed in Section 16035-1.3. In addition, include information for Raceways and Boxes (16110).

END OF SECTION 16045

SECTION 16060 – IDENTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide fixed identification of all distribution equipment and conductors in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000
 - 1. Wire and Cable - Section 16120
 - 2. Panelboards - Section 16160
 - 3. Disconnect Switches and Enclosed Circuit Breakers - Section 16170
 - 4. TVSS - Section 16400
 - 5. Switchboards - Section 16440
 - 6. Luminaires and Accessories - Section 16500
 - 7. Fire Alarm System - 16721

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest recommendations of the following.
 - 1. Industry standards shall apply.

PART 2 - PRODUCTS

- 2.1 Unless otherwise noted, nameplates shall be black bakelite plates with white engraved upper case letters enclosed by white border on beveled edge.
- 2.2 Nameplates for equipment supplied by the emergency system shall be red bakelite with white lettering.
- 2.3 All nameplates must be engraved and must be secured with rivets, brass or cadmium plate screws. The use of Dynamo type or the like is unacceptable.
- 2.4 Lettering heights unless otherwise noted must be as follows:

<u>Items</u>	<u>Lettering Height</u>
Switchboards & Unit Substations	2"
Motor Control Centers	2"
Panelboards & Load Centers	1/2"
Feeder Switches	1/4"
Disconnect Switches	1/2"
Feeder Switches (Fuse Identification)	1/4"
Remote Smoke Detector Lamps	1/8"
Wall Plates	1/8"

Motor Controllers	1/4"
TVSS Cabinet	1/4"

- 2.5 Cable tags must be flameproof secured with flameproof non-metallic cord.
- 2.6 Nameplate inscriptions must bear the name and number of equipment to which they are attached as indicated on the Drawings. The engineer reserves the right to make modifications in the inscription as necessary.
- 2.7 The Engineer reserves the right to request additional nameplates at time of review of shop drawings and upon site observations. These shall be furnished at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 SWITCHBOARDS, SUBSTATIONS MULTIPLE METER CENTERS, AND MOTOR CONTROL CENTERS

- A. Furnish and install a master nameplate for each switchboard, and motor control center engraved with the equipment identification indicated on the Drawings. Mount at top of incoming section.
- B. Provide on each main switch an identifying nameplate. Where multiple mains are employed each switch shall be numbered. Inscription shall be "MAIN SWITCH" or "MAIN SWITCH NO. 1" et al.

3.2 PANELBOARDS AND LOAD CENTERS

- A. Furnish and install a nameplate for each panelboard and load center engraved with the identification indicated on the Drawings. Mount at top of panel.
- B. After installations are complete, provide and mount under sturdy transparent shield in the directory frame of each panel door, a neat, accurate and carefully typed directory properly identifying the lighting, receptacles, outlets, and equipment each overcurrent device controls.
- C. Include on directory the panel or load center identification, the cable and raceway size of panel feeder, and the feeder origination point.

3.3 DISCONNECT SWITCHES

- A. Furnish and install a nameplate for each disconnect switch engraved with the equipment designation which the disconnect serves.

3.4 MOTOR CONTROLLERS

- A. Furnish and install a nameplate for each motor controller or combination motor controller for both individual motor controllers and those in a motor control center, etc. Engraving must indicate the motor served and the type of service (eg. AC-8 - 1st floor supply, EF-2 - electric closet exhaust).

3.5 FEEDER SWITCHES

- A. Furnish and install for each feeder switch including, but not limited to those in switchboards, those in switch and fuse panelboards, those take-offs at bus ducts, those in motor control centers, those in multiple meter center, etc, two (2) nameplates as follows.
 - 1. The first nameplate must be white background with red lettering. Engraved with the words "REPLACE ONLY WITH _____ FUSE". Engrave with the proper fuse trade named and ampere rating (i.e. Bussmann LPS-R 100).

2. The second nameplate shall indicate the load served, the size and type of cable and raceway example:

LP-4, LP-5, LP-6
4-500 KCMIL-THHN-CU-3-1/2"C.

3.6 REMOTE SMOKE DETECTOR LAMPS AND TEST STATIONS

- A. Furnish and install a nameplate on each remote smoke detector lamp and/or test station. Engraving must indicate the location of the device to which the lamp is connected as approved by the Engineer.

3.7 SWITCHES

- A. Furnish and install an engraved nameplate for each switch controlling loads which are not local to the switch. Engraving shall be as directed by the Engineer.

3.8 PULLBOXES, ENCLOSURES AND CABLE TERMINATIONS

- A. Furnish and install cable tags on each cable which enters a pullbox, enclosure, switchboard and at terminations. Mark tags with type written inscription noting the load served, type and size of cable and the overcurrent device protecting the cable.

3.9 FIRE ALARM PHONE JACKS AND WARDENS STATIONS

- A. Furnish and install a nameplate on each wardens station and portable fire alarm phone jack. Engraving must indicate the floor and location of the station.

3.10 HIGH VOLTAGE RACEWAYS (OVER 600 VOLTS)

- A. Furnish and install on each high voltage raceway the following as conditions permit.
 1. Exposed
 - a. Self adhesive labels on each raceway at every floor level and not more than 25' on center. Labels are to be of a conspicuous color and note the operating voltage of the conductors so enclosed.
 2. Concealed Below Grade or Concrete
 - a. Concrete insert type markets above each raceway at every floor level and not less than 25' on center. Inserts are to be 4" in diameter of non-ferrous metal fit flush with finished service. Inscription to state size of raceway and cable operating voltage and date of installation.

3.11 FREEZE PROTECTION

- A. Install decal type labels on each pipe which is provided with freeze protection.
- B. Labels shall be inscribed "CAUTION -- ELECTRIC HEAT TRACING"
- C. Affix labels to the thermal insulation not more than 25' on center but not less than every length of pipe.

3.12 FIRE ALARM TERMINAL CABINETS

- A. Furnish and install on each fire alarm terminal cabinet an approved nameplate.

- B. Nameplates shall indicate floor and where multiple terminal cabinets are installed a prime designation for each cabinet (e.g. FATC-1B).

3.13 CAPPING AND STAKING

- A. Wherever raceways are for future use and are terminated outside of the structure, stake the location with a 2' long 1" x 1" wooden stake having a conspicuous color flag.
- B. Provide metal markers inserted into 8" D x 12" concrete ballast at all raceway terminations exterior to the structure. Inserts must state the date the raceway was installed, the size of the raceway and the point of the raceway termination.

3.14 LUMINAIRES

- A. Where connected to other than 120 volt circuit, provide each fluorescent or high intensity discharge fixture with the ballast voltage stenciled on the ballast cover in letters not less than 1/2 inch high.

3.15 TRANSIENT VOLTAGE SURGE SUPPRESSION CABINETS (TVSS)

- A. Provide nameplate on TVSS cabinet or box indicating category A, B, or C. Type of connection, i.e. (L-G), (L-L), (N-G), (L-N).

3.18 ELECTRICAL DEVICES

- A. Provide each electrical device with a panel and circuit number label.

END OF SECTION 16060

SECTION 16102 - EQUIPMENT CONNECTIONS AND COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide final connections to equipment and coordinate same in accordance with the Contract documents.
- B. Equipment to receive final connections shall include but not be limited to the following:
 - 1. Motors and Equipment
 - 2. Appliances
 - 3. Owner Furnished Equipment
- C. Related Work Specified in Division 16000
 - 1. Testing and Acceptances - Section 16065
 - 2. Raceways and Boxes - Section 16110
 - 3. Wire and Cable - Section 16120
 - 4. Disconnect Switches - Section 16170
 - 5. TVSS - Section 16400
 - 6. Grounding Systems - Section 16450
- D. Related Work Specified in Other Division of these Specifications:
 - 1. Motors
 - 2. FF&E Package
 - 3. Control Wiring
 - 4. Appliances

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations.

1.1 QUALITY ASSURANCE

- A. Prior to the submitting of bids, the Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment requiring electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment and the coordination thereof.

- B. Connections shall be made in accordance with the manufacturer's recommendations and approved shop drawings.

PART 2 - PRODUCTS

2.1 (NOT USED)

PART 3 - EXECUTION

3.1 EQUIPMENT

- A. Connections for and coordination of motors and equipment requiring electrical connections shall include but not be limited to the following:

1. Provide and install a disconnect switch for each motor and each piece of equipment. Provide disconnects where required by code.
2. Verify that the motor rotation is correct and reconnect if necessary.
3. Provide separate ground wires in flexible, metal conduit and non-metallic conduit so as to provide an electrically continuous ground path. Ground all equipment.
4. Provide motor branch circuit conductors and connections to each individual motor controller and from each controller to the motor through an approved disconnect switch. Make final connection in minimum 24-inch length of liquid-tight, flexible, metal conduit.
5. Where equipment is fed from branch circuit routed in or under the slab, terminate branch circuit at junction box on 24-inch rigid conduit stub-up and make final connection to equipment in liquid-tight, flexible, metal conduit. Provide suitable knee brace on conduit stub-up.
6. Where equipment is fed from overhead support conduit feeder descending from ceiling on flanged floor fitting with conduit type fitting connecting to motor with 24-inch minimum of liquid-tight flexible steel conduit.
7. Where nameplate on equipment indicates fuse protection the disconnecting means shall be equipped with dual element, time-delay fuses.

3.2 APPLIANCES

- A. Connections for and coordination of appliances shall include but not be limited to the following:

1. The basic requirements for motors and equipment specified above shall apply where applicable.
2. Where cord and plugs are provided with the appliances this contractor shall coordinate the receptacle installation to match.
3. Direct connected equipment shall be serviced by disconnecting means.

3.3 OWNER FURNISHED EQUIPMENT

- A. The requirement for equipment furnished by the owner for installation by this contractor shall include but not be limited to the following:

1. The coordination of the proper delivery scheduling of such equipment.
2. The receiving and unloading of such equipment at the property line.
3. The inspection of such equipment for damages, defacement, corrosion, missing components, etc. at the job site. All deficiencies shall be recorded. Deficiencies occurring after inspection shall be corrected by this contractor at his cost.
4. The safe handling at secure storage of such equipment from unloading to the time of permanent installation.
5. The completion of field make up of internal wiring as required.
6. The lamping of equipment.
7. The installation of accessories on such equipment.
8. The installation of such equipment including the transportation of the equipment to the installation area, and the installation of all supports, fasteners, canopies, extensions, etc. required to insure safe support and adaptation to the finished structural, electrical and architectural conditions.
9. The final connections and grounding to the building electrical system including all necessary labor and materials including but not limited to junction box extensions, lug change outs, etc.
10. The testing of such equipment in its final location.

3.4 ELECTRICAL/MECHANICAL COORDINATION

- A. Furnish electrical services to Division 15 equipment as outlined below.
- B. Unless otherwise indicated, all mechanical equipment motors and controls shall be furnished, set in place, and wired By the Division 15 Contractor. Contractor should note that the intent of this wiring schedule is to have the Division 15 Contractor responsible for coordinating all control wiring regardless of voltage as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 15 for electrical work of this Division 16 that is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Division 16 Contractor shall refer to the Division 15 specifications and plans for all power wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

Item	Furnished By	Set By	Power Wiring	Control Wiring
Equipment Motors	MC	MC	EC	TC
Motor Starters and Thermal Overload Heaters (See Note 1)	MC	MC	EC	TC
Control Wiring Regardless of Voltage	TC	TC	TC	TC
Control Relays & Transformer (See Note 2)	TC	TC	TC	TC

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Item	Furnished By	Set By	Power Wiring	Control Wiring
Temperature Control Panels, Timeclocks, Controllers	TC	TC	TC	TC
Thermostats (Line Voltage) including Aquastats	MC	EC	EC	MC
Motor & Solenoid Valves, Damper Motors, PE & EP Switches, Control Valves, Fan Interlocking Wiring, Low Voltage Thermostats	TC	TC	TC	TC
Building Fire Alarm System Fire & Smoke Detectors, including Relays for Fan Shutdown	EC	EC	EC	EC
Fire Protection (Exterior horn & light)	FPC	EC	EC	EC
Fire Sprinkler System Alarms, Tamper Switches, Flow Switches and Fire Alarm Systems Tie-ins to provide a complete Fire Protection System	FPC	FPC	EC	EC
Duct Detection (Note 6)	EC	MC	EC	EC
Remote Disconnect Switches for Pool and Water Heater Controls per ASME-CSD-1	TC	TC	EC	TC
Fire and Smoke Dampers	MC	MC	EC	EC
Manual Operating & Speed Switches (carrying load currents) (See Note 3 & 4)	MC	MC	EC	--
Pushbutton Stations & Pilot Lights (Manually operated Switches not carrying Load Currents) (See Note 3)	MC	MC	--	TC
Freeze Protection Heat Trace	MC	MC	EC	TC
Electric Freeze Protection Heat Cable (Snowmelt)	EC	EC	EC	EC
Fused and Unfused Disconnect Switches & Thermal Overload Switches	EC	EC	EC	--
HVAC Water Treatment Interlocks	MC	MC	TC	TC
Contactors	EC	EC	EC	EC
Temporary Heating Connections	MC	MC	EC	TC

MC = Mechanical Contractor Under Division 15 of the Work
EC = Electrical Contractor Under Division 16 of the Work
FPC = Fire Protection Contractor
TC = Temperature Control Contractor

Notes for the Electrical/Mechanical Coordination Schedule

1. All starters, other than those in Motor Control Centers and noted on the Drawings shall be furnished under Division 15. All starters furnished under Division 15 shall be complete with three overload heaters and shall conform to NEC and NEMA requirements. All starters shall have 65,000 AIC rating.
 2. Control relays and control transformers shall be furnished under Division 15 except where furnishing such items are specifically required under Division 16 specifications and/or drawings.
 3. Pushbuttons stations carrying full load current are to be wired under Division 16 of the work.
 4. Exhaust Fans: The Electrical Contractor under Division 16 of the work will furnish and install circuits, feeders and disconnect switches, and make all connections to motors and controls unless interlocked with other mechanical equipment or exhaust fans in locations indicated. Where exhaust fans are switched with lights, a two-pole toggle switch will be provided under Division 16. Where exhaust fans are interlocked with other mechanical equipment, the interlock wiring will be furnished by the Mechanical Contractor under Division 15.
 5. Electrical contractor shall provide disconnects for all starters and variable frequency drives. Electrical Contractor shall provide disconnects at the equipment if it is not in line of sight of starter disconnect.
 6. Electrical contractor provides control wiring to fire alarm panel. Mechanical contractor provides control wiring to mechanical unit.
- C. All temperature control conduit and wiring shall be furnished and installed under Division 15. All motorized damper equipment shall be furnished and installed under Division 15 and wired under Division 16.

END OF SECTION 16102

SECTION 16110 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide raceways in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000
 - 1. Identification - Section 16060
 - 2. Testing, Acceptances & Certifications - Section 16065
 - 3. Grounding - Section 16450
- C. Related Work Specified in Other Divisions of these Specifications
 - 1. Finish Painting
 - 2. Concrete

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. Rigid Metal Conduit (RMC)
 - a. UL Standard UL-6
 - b. ANSI C80.1
 - c. Federal Specification WW-C-581E
 - 2. Intermediate Metal Conduit (IMC)
 - a. UL Standard UL-1242
 - b. Federal Specification WW-C 581E
 - 3. Electrical Metallic Tubing (EMT)
 - a. UL Standard UL-797
 - b. ANSI C80.3
 - c. Federal Specification WW-C-563
 - 4. Flexible Metal Conduit (FMC)
 - a. UL Standard UL-1
 - 5. Liquidtight Flexible Metal Conduit (LFMC)
 - a. UL Standard UL-360
 - 6. Rigid Nonmetallic Conduit (RNC)

- a. NEMA TC2; Schedule 40 PVC
- 7. Electrical Nonmetallic Tubing (ENT)
 - a. NEMA TC13
- 8. Wireways and Auxiliary Gutters
 - a. UL Standard 870

1.3 SUBMITTALS

- A. Provide listing of manufacturers proposed in the submittal list identified in Section 16035 of these specifications.
- B. Where wireways and/or auxiliary gutters are employed full erection drawings must be submitted. Drawings to include plan views, elevations, size of wireways, type and quantity of conductors proposed to be installed therein, etc.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. RMC - Allied, Wheatland, Republic, LTV, Triangle.
- B. IMC - Allied, Wheatland, Republic, LTV, Triangle.
- C. EMT - Allied, Wheatland, Republic, LTV, Triangle.
- D. FMC - Triangle, Alflex, Galflex, Interflex, Condux.
- E. LFMC - Sealtite.
- F. RNC - Carlon, Certainteed, Condux, PWP.
- G. ENT - Carlon, PWP.
- H. Wireways & Auxiliary Gutters - Square D, Queen City Plastics, Unity.
- I. Outlet, Junction & Pull Boxes - Appleton, Steel City, Raco, Bowers, Hoffman, Queen City Plastics, Unity, Circle AW.

2.2 RACEWAY TYPES

- A. Standard Threaded Rigid Metal Conduit (RMC)
 - 1. Rigid conduit heavy wall galvanized
- B. Intermediate Metal Conduit (IMC)
 - 1. Light weight rigid steel conduit
- C. Electric Metallic Tubing (EMT)

1. Continuous, seamless tubing galvanized or sheradized on the exterior coated on the interior with a smooth hard finish of lacquer, varnish or enamel.
2. All couplings, connectors, etc., used in conjunction with this raceway which are 2 inch in size and smaller may be set screw type. Conduits of 2-1/2 inch in size and larger must employ steel compression gland fittings, "Tomic" tap-on or "Tomic" compression type or set screw type.
3. Where installed in slab or concrete work, provide approved concrete tight fittings.

D. Flexible Metal Conduit (FMC)

1. Single strip, continuous, flexible interlocked double-wrapped steel, galvanized inside and outside forming smooth internal wiring channel.
2. Maximum length: 6 feet
3. Each section of raceway must contain a bonding wire bonded at each end and sized as required. Provide connectors with insulating bushings.

E. Liquidtight Flexible Metal Conduit (LFMC)

1. Same as flexible metal conduit except with tough, inert watertight plastic outer jacket.
2. Cast malleable iron body and gland nut, cadmium plated with one-piece brass grounding bushings which thread to interior of conduit. Spiral molded vinyl sealing ring between gland nut and bushing and nylon insulated throat.

F. Rigid Nonmetallic Conduit (RNC)

1. PVC conduit shall be rated for 90°C operating temperature.
2. Conduit shall be a minimum of Schedule 40.

G. Electrical Nonmetallic Tubing (ENT)

1. Shall be rated for 90°C operating temperature.

H. Wireways and Auxiliary Gutters

1. Of sizes and shapes indicated on the Drawings and as required.
2. Provide all necessary elbows, tees, connectors, adaptors, etc.
3. Hinged cover secured with captive screws.
4. Wire retainers not less than 12 inches on center.

2.3 OUTLET, JUNCTION AND PULL BOXES

- A. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4 inches octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8 inch no-bolt fixture studs where required. Where fixtures are mounted on or in an accessible type ceiling, provide a junction box and extend flexible conduit to each fixture. Fit outlet boxes in finished ceiling or walls with appropriate covers, set flush with the finished surface. Where more than one switch or device is located at one

point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide Series "GW" (Steel City) tile box, or as accepted, or a 4 inch square box with tile ring in masonry walls which will not be plastered or furred. Where drywall material is utilized provide plaster ring. Provide outlet boxes of the type and size suitable for the specific application. Where outlet boxes contain 2 or more 277 volt devices, or where devices occur of different applied voltages, or where normal and emergency devices occur in same box, provide suitable barrier.

- B. Construct junction or pull boxes not over 150 cubic inches in size as standard outlet boxes, and those over 150 cubic inches the same as "cabinets", with screw covers of the same gauge metal.
- C. Plug any open knockouts not utilized.
- D. Provide surface mounted outlet and junction boxes in indoor locations where exposed to moisture and outdoor locations of cast metal with threaded hubs. All outdoor receptacles shall have tamper resistant cover plates.
- E. The covers of all junction boxes containing emergency power shall be painted red.

PART 3 - EXECUTION

3.1 APPLICATION OF RACEWAYS

- A. The following applications must be adhered to except as otherwise required by Code. Raceways not conforming to this listing must be removed by this Contractor and replaced with the specified material at this Contractors expense.

<u>Raceway Types</u>	<u>Application</u>
RMC	Where required for mechanical protection, where specifically indicated on the Drawings, where required by codes or utility company, in hazardous areas, underground 90° elbows, vertical risers (stub-ups) to panelboards, switches, equipment, etc., and for all circuits in excess of 600 volts.
IMC	Same as standard threaded RMC.
EMT	Use in every instance except where another material is specified.
FMC	Use in dry areas for final connections to lighting fixtures in hung ceilings, connections to equipment installed in removable panels of hung ceilings at bus duct takeoffs, at all transformer or equipment raceway connections where sound and vibration isolation is required.
LFMC	Use in areas subject to moisture where flexible steel is unacceptable at connections to all motors, and all raised floor areas.
RNC	Buried in earth and embedded in concrete slabs on earth. Do not use in areas where conduit will be exposed per New Mexico Electrical Code item N.
ENT	Where indicated on the Drawings and as otherwise specifically approved.
Wireways and Auxiliary Gutters	Where indicated on the Drawings and as otherwise specifically approved.

- C. The use of MC cable is approved for locations above finished ceilings, luminaire terminations and in framed interior walls. AC cable is not permitted.

3.2 RACEWAY SYSTEMS IN GENERAL

- A. Provide raceways for all wiring systems, 277/480 volt wiring must be kept independent of 120/208 volt wiring. All types of raceways (metallic and nonmetallic) shall have equipment grounding conductors. The equipment grounding conductor shall be considered an insulated conductor when sizing raceway. Minimum size 1/2 inch above grade, 3/4 inch below grade. Wiring of each type and system must be installed in separate raceways.
- B. Install capped bushings on raceways as soon as installed and remove only when wires are pulled. Securely tie embedded raceway in place. Raceways installed below or in floor slabs must extend a minimum of 4 inches above the finished slab to the first connector. Lay out the work in advance to avoid excessive concentrations of multiple raceway runs.
- C. Locate raceways so that the strength of structural members is unaffected and they do not conflict with the services of other trades. Install 1-inch or larger raceways in or through structural members (beams, slabs, etc.) only when and in the manner accepted by the Architect/Engineer. Draw up couplings and fittings full and tight. Protect threads from corrosion with one (1) coat red lead and zinc chromate after installation.
- D. Above Grade - Defined as the area above finished grade for a building exterior and above top surface of any slabs (or other concrete work) on grade for a building interior. Above-grade raceways to comply with the following:
 - 1. Install raceways concealed except at surface cabinets and for motor and equipment connections in electrical and mechanical rooms. Install a minimum of 6 inches from flues, steam pipes, or other heated lines. Provide flashing and counter-flashing for waterproofing of raceways, outlets, fittings, etc., which penetrate the roof. Route exposed raceways parallel or perpendicular to building lines with right-angle turns and symmetrical bends. Run concealed raceways in a direct line and, where possible, with long sweep bends and offsets. Provide sleeves in forms for new concrete walls, floor slabs and partitions for passage of raceways. Waterproof sleeved raceways where required.
 - 2. Provide raceway expansion joints for exposed and concealed raceways with necessary bonding conductor at building expansion joints and between buildings or structures and where required to compensate for raceway or building thermal expansion and contraction.
 - 3. Provide one (1) empty 3/4 inch raceway for each three (3) spare unused poles or spaces of each flush-mounted panelboard. Terminate empty 3/4 inch conduit in a junction box, which after completion, is accessible to facilitate future branch circuit extension.
 - 4. Provide raceway installation (with appropriate seal-offs, explosion-proof fittings, etc) in special occupancy area, as required. Provide conduit seal-offs where portions of an interior raceway system pass through walls, ceiling or floors which separate adjacent rooms having substantially different maintained temperatures, as in refrigeration or cold storage rooms.
 - 5. Provide drag wire in all spare or empty raceways and in those which the Contractor has elected to install. Tag both ends of wire denoting opposite end termination location with black india ink on flameproof linen tag. Identify special system (POS, PC, TV, etc.) conduits in the method described above.
- E. Below Grade: Defined as the area below finished grade for a building exterior and below or within the bottom floor slab for a building interior. Below grade raceways to comply to the following:

1. Duct banks shall be installed to drain away from buildings; ducts between handholes and pull boxes shall drain toward the handholes. Duct slopes shall not be less than 3 inches per 100 feet.
2. Duct banks shall be reinforced as shown on the Drawings.
3. Conduits shall be laid in trenches on a clean backfill bedding not less than 6 inches thick and well graded.
4. Where indicated on the drawings underground conduits shall be encased in a 3-inch concrete envelope of 1-3-5 mix unless indicated otherwise and arranged in tiers. Banked conduits shall be held securely in place, at a minimum 1 -inch spacing between conduits, by approved separators installed at 5 ft. intervals.
5. Top 2 inches of all concrete envelopes to be mixed with 10 pounds of iron oxide per cubic yard.
6. Where indicated on the drawings conduits running under the building shall have a 2" concrete cap. Concrete in cap to be mixed with 10 pounds of iron oxide per cubic yard.
7. The minimum cover for conduits shall be 24 inches unless otherwise permitted by Engineer.
8. Conduit entrances to buildings and structures shall be made with galvanized RMC.
9. Where bends in conduits are required, long radius elbows, sweeps, and offsets shall be used.
10. All conduits shall be rodded and a mandrel drawn through followed by a swab to clean out any obstructions which may cause cable abrasions. The mandrel shall be 12 inches in length and the diameter 1/2 inch less than the inside diameter of the conduit.
11. Spare conduits shall be plugged and sealed watertight at all handholes, pull boxes, buildings and structures.
12. Conduits in use shall be sealed watertight at all handholes, pull boxes, buildings and structures.
13. All exposed conduit shall be galvanized RMC.
14. RNC (PVC) joints shall be made so as to prevent the passage of concrete inside the conduit to form obstructions or cause cable abrasions. A joint compound, approved for the purpose, shall be applied uniformly over the tapered surface before insertion into the coupling.
15. Handhole and pull box covers in streets shall finish flush with finished paving and in other areas shall finish 3 inches above crown of adjacent roadway.
16. Concrete monuments shall be provided at each stubbed conduit location. Monuments shall be as shown on the Drawings and shall be installed in the same manner outlined for manhole covers.
17. All underground conduit shall be RNC (PVC), except vertical risers and elbows. Vertical risers to panelboards, switches, equipment, etc. and 90° elbows shall be galvanized RMC.
18. Provide raceway expansion joints where required to compensate for raceway thermal expansion and contraction.

- F. Conduits and sleeves of any material not harmful to concrete and within limitations listed below may be embedded in concrete with approval of the Structural Engineer, provided they are not considered to replace structurally the displaced concrete.
1. Conduits of aluminum shall not be embedded in structural concrete unless effectively coated or covered to prevent aluminum-concrete reaction or electrolytic action between aluminum and steel.
 2. Conduits and sleeves passing through a slab, wall, or beam shall not impair significantly the strength of the construction.
 3. Conduits with their fittings, embedded within a column shall not displace more than 4 percent of the area of cross section on which strength is calculated or which is required for fire protection.
 4. Except when plans for conduits are approved by the Structural Engineer, conduits embedded within a slab, wall, or beam (other than those merely passing through) shall satisfy the following:
 - a. They shall not be larger in outside dimension than $1/3$ the overall thickness of slab, wall, or beam in which they are embedded.
 - b. They shall not be spaced closer than 3 diameters or widths on center.
 - c. They shall not impair significantly the strength of the construction.
 - d. Conduits and sleeves may be considered as replacing structurally in compression the displaced concrete provided.
 - e. They are not exposed to rusting or other deterioration.
 - f. They are of uncoated or galvanized iron or steel not thinner than standard Schedule 40 steel pipe.
 - g. They have a nominal inside diameter not over 2 inches and are spaced not less than 3 diameters on centers.
 - h. Raceways running parallel to slabs supports, such as beams, columns and structural walls, shall be installed not less than 12 inches from such supporting elements.
 - i. To prevent displacement during concrete pour of lift slab, saddle supports for conduit, outlet boxes, junction boxes, inserts, etc., shall be secured with suitable adhesives.
- G. Raceways in hung ceilings shall be run on and secure to slab or primary structural members of ceiling, not to latching channels or T-bars, Z-bars or other elements which are the direct supports of the ceiling panels. Secure conduit firmly to steel by clips and fittings designed for that purpose. Install as high as but not less than 1'-0" above hung ceilings.
- H. Exposed raceways shall be run parallel or at right angles with building lines. Secure raceway clamps or supports to masonry materials to toggle bolts, expansion bolts, or steel inserts. Install raceway on steel construction with approved clamps which do not depend on friction or set-screw pressure alone.

- I. Clear raceway of all obstructions and dirt prior to pulling in wires or cables. This shall be done with ball mandrel (diameter approximately 85% of conduit inside diameter) followed by close fitting wire brush and wad of felt or similar material. This assembly may be pulled in together with, but ahead of the cable being installed. All empty raceways shall be similarly cleaned. Clear any raceway which rejects ball mandrel.
- J. Support less than 2" trade size, vertically run, raceways at intervals no greater than eight feet. Support such raceways, 2" trade size or larger, at intervals no greater than the story height, or fifteen feet, whichever is smaller.
- K. Support less than 1" trade size, horizontally run, raceways at intervals no greater than seven feet. Support such raceways, 1" trade size or larger, at intervals no greater than ten feet.

3.3 WIREWAYS AND AUXILIARY GUTTER

- A. Wireways installed in hung ceilings shall be placed such that the cover will hinge upward from the side.
- B. 12" clear shall be provided from wireway cover when it is in the open position.

3.4 OUTLET, JUNCTION AND PULL BOXES

- A. Provide outlet, junction, and pull boxes as indicated on the Drawings and as required for the complete installation of the various electrical systems, and to facilitate proper pulling of wires and cables. Junction boxes and pull boxes shall be sized per NEC minimum.
- B. The exact location of outlets and equipment is governed by structural conditions and obstructions, or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to the room layout and will not interfere with other work or equipment. Verify final location of outlets, panel equipment, etc., with Architect.
- C. Back-to-back outlets in the same wall, or "thru-wall" type boxes not permitted. Provide 12-inch (minimum) spacing for outlets shown on opposite sides of a common wall to minimize sound transmission.

3.5 SEALS

- A. Underground. Where underground conduits pass from an area of one classification to another or to an unclassified area, a seal fitting shall be installed in the less hazardous area, usually at a stub-up. Seal fittings are not required at the stub-ups of underground runs if both stub-ups are in an area of the same classification and the conduit run does not traverse under an area of different classification. Seal fittings are required at all conduit stub-ups in unclassified areas where any portion of the underground conduit run passes through or under a Division 1 or 2 classified area, or through soil that may contain hydrocarbons. This frequently required that underground conduits terminating under a motor control center or switchgear be sealed.
- B. Aboveground. All overhead conduit passing from an area of one classification to an area of another classification shall be sealed on either side of the classification boundary but not on both sides. There shall be no unions, couplings, boxes or fittings in the conduit between the seal and the classification boundary.
- C. Sealing enclosures. Sealing of enclosures containing arcing or high temperature devices shall be done in accordance with NEC Article 501. In Class 1, Division 1 areas 2 inch or larger conduit must be sealed at enclosures containing splices, taps, or terminals.

3.6 DRAIN FITTINGS

- A. All overhead conduit systems shall be provided with suitable drain fittings at the low point of vertical runs. If sealing is required in a vertical run, a drain seal fitting shall be installed. To the extent possible, drain fittings shall not be installed until after internal conduit cleaning.

END OF SECTION 16110

SECTION 16120 - WIRE AND CABLE (600 VOLTS AND LESS)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide 600 volt wire and cable in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000.
 - 1. Identification - Section 16060
 - 2. Testing, Acceptances and Certification - Section 16065
 - 3. Raceways and Boxes - Section 16110

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. Conductors
 - a. ASTM
 - b. NEMA WC 5
 - 2. Terminal Blocks
 - a. UL-1059

1.3 SUBMITTALS

- A. Provide listing of manufacturers proposed in the submittal list identified in Section 16035 of these specifications.

PART 2 - PRODUCTS

A. APPROVED MANUFACTURERS

- A. Wire and Cable
 - 1. Triangle, General Cable, Okonite, Simplex, Southwire, Kerite, Rome.
- B. Connectors
 - 1. Hand Applied
 - a. "Wing Nut" (Ideal Industries), "Piggy" (Thomas & Betts) or "Scotchlok" (3M Company).
 - 2. Tool Applied

- a. Manufacturer: "Scotchlok" S-11, S-31 (3M Company), "Sta-Kon" (Thomas & Betts), "Number 410 Crimp Connector" (Ideal Industries), or "Wrap-Cap" (Buchanan).

C. Electric Tape

1. Johns-Manville or 3M Company

2.2 WIRE AND CABLE

A. General

1. Provide wire with a minimum insulating rating of 600 volts, except for wire used in 50 volts or below applications for control of signal systems use 300 volt minimum or 600 volt where permitted to be incorporated with other wiring systems.

B. Conductor

1. Electrical grade, annealed copper, tinned if rubber insulated, and fabricated in accordance with ASTM standards. Minimum size 12 AWG for branch circuits; 14 AWG for control wiring.
2. All conductors are copper unless specifically noted on the plans.

C. Stranding and Number of Conductors

1. Conductors larger than 10 AWG, stranded in accordance with ASTM Class B stranding designations.
2. Control wires stranded in accordance with ASTM Q Class B stranding designations.
3. Cables, multi-conductor unless otherwise noted for low tension systems.

D. Insulation

1. Type THHN- Heat-resistant thermoplastic insulation, nylon jacket rated for 90°C operation. Use for all conductors in dry locations unless otherwise noted on the Drawings.
2. Type THWN-Thermoplastic insulation, nylon jacket rated for 75°C operation. Use for conductors in wet locations.
3. Consult equipment manufacturer for insulation type when installation requires an insulation rating above 90°C.

E. Color Coding

1. Provide consistent color coding of all feeders, sub feeders, motor circuits and the like as follows:

120/208 Volts Code

Phase A - Black

Phase B - Red

Phase C - Blue

Neutral - White

Ground - Green

Switch Travelers - Pink

277/480 Volt Code

Phase A - Brown

Phase B - Orange

Phase C - Yellow

Neutral - Gray

Ground - Green with Yellow Stripe

Switch Travelers - Purple

2. Color-code wiring for control systems installed in conjunction with mechanical and/or miscellaneous equipment in accordance with the wiring diagrams furnished with the equipment. Factory color code wire 8 AWG and smaller. Wire 6 AWG and larger may be color coded by color taping of the entire length of the exposed ends.

2.3 CONNECTORS

- A. Make connections, splices, taps and joints with solderless devices, mechanically and electrically secure. Protect exposed wires and connecting devices with electrical tape or insulation to provide not less than that of the conductor.
- B. Branch Circuit wires (10 AWG and smaller): Use any of the following types of terminals and connecting devices:
 1. Hand applied
 - a. Coiled tapered, spring wound devices with a conducting corrosion-resistant coating over the spring steel and a plastic cover and skirt providing full insulation for splice and wired ends. Screw connector on by hand.
 2. Tool applied
 - a. Steel cap, with conduction and corrosion resistant metallic plating, open at both ends, fitted around the twisted ends of the wire and compressed or crimped by means of a special die designed for the purpose. Specifically fitted plastic or rubber insulating cover wrap over each connector.

2.4 ELECTRICAL TAPE

- A. Specifically designed for use as insulating tape.

2.5 LUBRICANT

- A. Use lubricant only where the possibility of damage to conductors exists. Use only a lubricant approved by the cable manufacturer and one which is inert to cable and raceways.

PART 3 - EXECUTION

3.1 WIRE AND CABLE

- A. Provide a complete system of conductors in raceway system. Mount wiring through a specified raceway, regardless of voltage application.

- B. Drawings do not indicate size of all branch circuit wiring. For 15- and 20-ampere branch circuits whose length from panel to furthest outlet or luminaire exceeds 100 feet for 120-volt circuits or 200 feet for 277-volt circuits, use conductors 10 AWG or larger. Limit voltage drop of branch circuiting to three (3) percent of system voltage or less.
- C. Do not install wire in incomplete conduit runs or until after the concrete work and plastering is completed and moisture is swabbed from conduits. Eliminate splices wherever possible. Where necessary, splice in readily accessible pull, junction, or outlet box.
- D. Provide cable supports for all vertical risers where required by code not to exceed the following:

<u>Minimum Conductor Size</u>	<u>Vertical Supports</u>	
	<u>Aluminum</u>	<u>Copper</u>
18 AWG through 8 AWG	100 ft	100 ft
6 AWG through 1/0 AWG	200 ft	100 ft
2/0 AWG through 4/0 AWG	180 ft	80 ft
Over 4/0 AWG through 350 KCMIL	135 ft	60 ft
Over 350 KCMIL through 500 KCMIL	120 ft	50 ft
Over 500 KCMIL through 750 KCMIL	95 ft	40 ft

- E. Flashover or insulation value of joints to be equal to that of the conductor. Provide Underwriters' Laboratories listed connectors rated at 600 volts for general use and 1000 volts for use between ballasts and lamps or gaseous discharge fixtures.
- F. Use terminating fittings, connectors, etc., of a type suitable for the specified cable furnished. Make bends in cable at termination prior to installing compression device. Make fittings tight.
- G. Install wire in raceways and make up terminations in accordance with manufacturer's recommendations using special washers, nuts, etc., as required. Use an accepted wire-pulling lubricant equivalent to "Yellow" (Ideal) for all wire 4 AWG and larger. Strip insulation so as to avoid nicking of wire.
- H. Extend wire sizing for the entire length of a circuit, feeder, etc. unless specifically noted otherwise.
- I. Isolated ground circuits to have a dedicated neutral wire and a dedicated ground wire. Sharing of these wires with other circuits is not permissible.
- J. A 10 AWG copper neutral conductor shall be used for all isolated ground circuits.

3.2 TESTING

- A. See specification 16065 for testing requirements.

END OF SECTION 16120

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide wiring devices in accordance with the Contract Documents.
- B. Related work Specified in Division 16000
 - 1. Electrical General Provisions (Mounting Heights) - Section 16010
 - 2. Identification - Section 16060
 - 3. Raceways and Boxes - Section 16110
 - 4. Wire and Cable - Section 16120
 - 5. Grounding Systems - Section 16450
- C. Related Work Specified in Other Divisions of these Specifications
 - 1. Finish painting

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. Switches
 - a. Federal Specification Standard WS-896E
 - b. UL Standard 20
 - 2. Receptacles
 - a. NEMA Standard WD-1, 3.02 through 3.10
 - b. UL Standard 498
 - c. Federal Specification WC596

1.3 SUBMITTALS

- A. Submit manufacturer's catalog cuts and specifications for all wiring devices and plates.
- B. Switches and receptacles shall be of the same manufacturer.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. Hubbell, Arrow Hart, Pass & Seymour, Leviton or approved equal

1. Switches
 - a. Hubbell - HBL1220 Series
2. Switch and Pilot Light
 - a. Hubbell - HBL1221 PL
3. Duplex Convenience Receptacles
 - a. Hubbell - HBL5362
4. Faceplates
 - a. Nylon: Hubbell P Series
 - b. Stainless steel: Hubbell S Series
5. Outdoor Receptacles
 - a. Hubbell - HBL5362
6. Ground Fault Circuit Interrupters
 - a. Hubbell GF5362
7. Isolated Ground Receptacles
 - a. Hubbell - IG5362

2.1 SWITCHES

A. Switches

1. Provide specification grade, flush mounting, quiet-operating AC type, with toggle operator, heat-resistant plastic housing and self grounding metal strap. Silver alloy contact. Rated 20A at 120-277V and capable of full capacity on tungsten or fluorescent lamp load. Design for side or back wiring with up to 10 AWG wire. Verified by UL to meet or exceed Federal specification WS-896E.

- B. Use single-pole, double-pole, 3-way, 4-way, pilot or keyed type, as indicated on Drawings or required.
- C. Switches controlling lighting connected to the emergency power system shall be red and of the illuminated toggle type-illuminated when the switch is in the off position.
- D. Switches controlling lighting by way of low-voltage lighting control relays shall be 3-position, momentary-contact, center-off type to match the other switches.
- E. Switch and Pilot Light: Switch as indicated with red neon pilot light.
- F. Color of normal devices as selected by Architect.

2.2 DUPLEX CONVENIENCE RECEPTACLES

- A. Provide 3-pole NEMA and ANSI standard type, with bronze contacts that accept plug with 2 parallel blades and 1 grounding blade. Heat-resistant plastic enclosure with nylon face and green grounding screw. Break-off terminals for 2-circuit wiring. Rated 20 amperes at 125-volt electrical alternating current.
- B. All devices connected to the emergency system shall be red.
- C. Color of normal devices as selected by Architect.

2.3 FACEPLATES

- A. Provide cover plates for wall receptacles, outlets, and switches of nylon to match device finish, unless otherwise noted. When two or more switches or devices are shown in one location, mount under a common plate.

2.4 OUTDOOR LOCATIONS

- A. Each receptacle installed in a damp location shall be corrosion resistant having all metal parts from stainless steel or be nickel plated brass.
- B. Protect exterior switches and those in mechanical rooms which act as plenums by a cast aluminum metal plate with a fiber shield and spring loaded cover.
- C. Protect exterior receptacles and in those mechanical rooms which act as plenums with Weatherproof In-Use aluminum NEMA 3R covers, Hubbell WP8M or engineer-approved equal.
- D. Where indicated or required provide ground fault circuit interrupters which will interrupt leakage currents between 4 and 6 mA having a maximum circuit current of 20 amperes. Employ feed through devices as required.

PART 3 - EXECUTION

3.1 SWITCHES

- A. Install switches square and true to building surfaces. Install in locations shown on the Drawings. Mounting height shall be 48" above floor unless noted otherwise. Mount switches vertically with the "on" position on top, unless noted or specified otherwise.
- B. Where switches are indicated to be installed near doors, corner walls, etc., mount same not less than 2 inches and not more than 12 inches from trim. Verify exact location with the Architect.
- C. Carefully coordinate the location of switches to insure locations at the strike side of doors.
- D. Furnish and install an engraved legend for each switch that controls motors, equipment systems, etc., not located within sight of the controlling switch.
- E. All wallbox dimmers shall be mounted under a separate cover plate. Do not gang with other devices.

3.2 RECEPTACLES

- A. Install receptacles square and true to building surfaces. Install in locations shown on the Drawings. Mount devices vertically with ground pin on bottom. Mount 18" above floor unless otherwise indicated herein or on the Drawings. Receptacles shown above counter shall be mounted vertically 6" above counter or backsplash. Unless otherwise noted, receptacles installed in brick or masonry wall shall be horizontal.

- B. Prior to final payment replace broken faceplates, switches and receptacles.

END OF SECTION 16140

SECTION 16155-INDIVIDUAL MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide individual motor controllers in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000.
 - 1. General Electrical Provisions (Supports and Hangers) - Section 16010
 - 2. Identification - Section 16060
 - 3. Testing, Acceptances and Certification - Section 16065
 - 4. Equipment Connection and Coordination - Section 16102
 - 5. Raceways and Boxes - Section 16110
 - 6. Disconnect Switches - Section 16170
 - 7. Fuses 600 Volts or Less - Section 16181

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. U.L. Standards 547, 845 and 1004.

1.3 SUBMITTALS

- A. Submit the following manufacturer's data and shop drawings for each individual motor controller:
 - 1. Drawings showing dimensions and mounting arrangements of enclosures.
 - 2. Elementary control wiring diagrams.
 - 3. Unit wiring diagrams for each motor controller.
 - 4. Nameplate nomenclature.
 - 5. Short circuit rating of complete motor controller assembly.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. Approved manufacturers of individual motor controllers shall be the same as for switchgear, panelboards, etc. All equipment shall be of the same manufacturer.

2.2 BASIC REQUIREMENTS

- A. Provide combination type individual motor controllers with fused disconnect switches and magnetic starters in common enclosure, or provide manual motor starters with overload protection. Provide all necessary control and pilot devices as required for satisfactory operation of equipment to be controlled.
- B. Controllers with magnetic starters shall be rated for 480 volt/3-phase/60Hz operation. Manual starters shall be rated for 120 volt/1-phase/60Hz operation unless otherwise noted.
- C. Provide controllers, with magnetic starters, with short circuit ratings as required by the Drawings or by actual available short circuit currents.
- D. Provide identification and testing in accordance with Section 16060 and 16065.

2.3 CONTROLLER DISCONNECT SWITCH

- A. Provide a horsepower rated fused disconnect switch as part of each individual combination magnetic motor controller. Each combination controller shall have a heavy duty, 3 pole, single throw knife switch, with a quick make-quick break mechanism suitable for motor full load operations.

2.4 ENCLOSURES

- A. Individual motor controllers shall be mounted in NEMA Type 1A gasketed enclosures for typical indoor locations.

Utilize NEMA Type 3R for outdoor locations and NEMA Type 4 for other wet locations or locations subject to water spray or very high humidity.

- B. Provide enclosures for magnetic controllers with the following features:
 - 1. Hinged cover with lock.
 - 2. Interlock between switch and cover that prevents door opening with switch in "on" position. Also, provide a door interlock by-pass feature that utilizes a special tool or procedure.
 - 3. Capability to padlock switch handle in "on" or "off" position.
 - 4. Multiple knockouts in the sides and back (NEMA Type 1A enclosures only).
 - 5. Ability to mount enclosure on wall or floor on angle iron frame.

2.5 STARTERS

A. Provide the following types of motor starters as required:

Provide 120 volt/1-phase manual starters for motors less than 1/2 Hp. except where remote or automatic control is required. In such cases, provide FVNR magnetic starters. Provide manual starters with the following features:

1. Toggle-operated switch.
 - a. Switch handle-lock off feature.
 - b. Long life pilot light.
 - c. Thermal overload protection with properly sized heaters.
 - d. A label engraved on nameplate or faceplate.
2. Provide 480 volt/3-phase/60Hz, full voltage non-reversing (FVNR), magnetic starters for motors of 1 Hp up to 100 Hp. Provide contactor with 120 volt coil unless otherwise required.
3. Provide reduced voltage, non-reversing, auto transformer type, magnetic starters for motors 100 Hp and larger. Auto transformer shall be two winding, open delta connected type. Provide reduced voltage starters with the following features.
 - a. Adjustable timing relay for start to run transfer timing.
 - b. Closed transition from start to run motor connection.
 - c. 50%, 65% and 80% auto transformer taps, factory set at 50% and easily converted in the field to 65% or 80%.
 - d. 120 volt coils on starting and running contactors unless otherwise required.
4. Provide special purpose starters for special applications or as required by Drawings (i.e. reversing or two speed starters, duplex starters, Wye-Delta starters, variable frequency, etc.).

2.6 CONTROLS AND PILOT DEVICES

A. Provide the following controls, pilot devices and features with each FVNR and reduced voltage magnetic starter:

1. Two winding control circuit transformer with sufficient volt-amp (VA) capacity to supply the in-rush and continuous power requirements of the starter coil(s) and the control circuit(s). Minimum control transformer capacity shall be 200VA. Control transformer secondary to be 120 volts unless otherwise required but in no case shall it exceed 120V. Provide dual element fuse in each line of the control transformer primary. Engrave the required fuse size on the fuse block or adjacent thereto. Connect the control transformer primary to the motor branch circuit.

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2. Hand-Off-Automatic (HOA) maintained contact selector switch, unless otherwise required. Switch shall be built into cover.
3. Minimum of one green long life pilot lamp built into cover.
4. Minimum of four sets of Normally Open (N.O.) auxiliary contacts that are easily converted in the field to Normally Closed (N.C.) contacts.
5. Three phase, ambient temperature compensating, thermal overload relays with three properly selected heaters. Overload relays shall have a trip adjustment from at least 90% to 110% of heater rating. Trip setting shall be factory set at 100%. Provide pushbutton on cover for manual reset of overload relays. Furnish overload relays set for manual reset operation, although they shall be capable of being easily converted in the field to automatic reset.
6. The holding coils for the starter contactors shall provide inherent under-voltage protection. Contactors shall open when control circuit voltage drops to approximately 60% of nominal. When required by Drawings or necessitated by circumstance, provide under-voltage reset pushbutton on cover and a set of auxiliary contacts to prevent automatic restart of motor.
7. Terminal strip for both remote and local connections.
8. Any additional controls and pilot devices required for proper operation of the installation.

PART 3 - EXECUTION

3.1 INSTALLATION OF MOTOR CONTROLLERS

- A. Install individual motor controller on a nearby wall, within ten feet of motor to be controlled or adjacent to the motor on angle iron or uni-strut frame or as required by the Drawings. Do not mount on equipment or fan housings.
- B. Perform all necessary field modifications and adjustments to each individual motor controller to provide required operation.

3.2 MOTOR POWER AND CONTROL WIRING

- A. Provide motor branch circuit conductors and connections to each individual motor controller and from each controller to the motor. Make final connection in minimum 24 inch length of liquid-tight, flexible, metal conduit.
- B. Verify that the motor rotation is correct and reconnect if necessary.
- C. Provide separate ground wires in flexible, metal conduit and non-metallic conduit so as to provide an electrically continuous ground path. Ground all equipment.
- D. Where equipment is fed from branch circuit routed in floor, terminate branch circuit at junction box on 6 inch rigid conduit stub-up and make final connection to equipment in liquid-tight, flexible, and metal conduit.

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- E. Provide all necessary wiring and connections for interlocking, remote and automatic controls. Installation of equipment and wiring shall be in compliance with shop drawings and manufacturer's recommendations.

3.3 COORDINATION

- A. Review Division 15000 Contract Documents for required starter accessories, interlocks, etc. Failure to fully coordinate this item with the Division 15000 Contractor shall in no way relieve this Division 16000 Contractor from providing a complete, functional, and coordinated system as described.

END OF SECTION 16155

SECTION 16160 – PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide panelboards in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000
 - 1. General Electrical Provisions (Equipment supports) - Section 16010
 - 2. Reviews and Acceptances - Section 16035
 - 3. Identification - Section 16060
 - 4. Laundry and Kitchen Equipment - Section 16101
 - 5. TVSS - Section 16399
 - 6. Grounding Systems - Section 16450
- C. Related work Specified in Other Divisions of these Specifications.
 - 1. Finish painting

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and recommendations of the following:
 - 1. Panelboards
 - a. UL Standards 50 and 67
 - b. NEMA Standard PB1
 - 2. Circuit Breakers
 - a. UL Standard 489
 - b. Federal Standard W-C-375
 - c. NEMA Standard AB1

1.3 SUBMITTALS

- A. Refer to Section 16035 concerning the procedures and additional documents for submittals in concert with panelboard submittals. Submittals failing to meet the following criteria will be returned without a review or acceptance.
- B. With each panelboard drawing the following is required.

1. Show main devices and lug sizes; branch circuit device sizes and arrangement; bus ampacities; withstandability and short circuit rating; dimensions and construction; gutter and backbox dimensions; nameplate and legend; protective coating; and all pertinent details of panel, enclosure, cover, and method of securing cover and lock.

1.4 QUALITY ASSURANCE

- A. Each panelboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short-circuit rating shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such rating shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to each panelboard. Test data shall be submitted to the Engineer at time of submission of Acceptance Drawings.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. All panelboards are to be of the same manufacturer as the switchboards.
- B. 277/480 volts circuit breaker type lighting and appliance panelboards shall be equal to Square D Type NF unless otherwise noted on the one-line diagram(s), panel schedules, or as required by panel size or branch breaker sizes.
- C. 120/208 volts circuit breaker type lighting and appliance panelboards shall be equal to Square D Type NQOD unless otherwise noted on the one-line diagram(s) or panel schedules.
- D. Power distribution panelboards shall be equal to Square D I-Line unless otherwise noted on the one-line diagram(s), panel schedules, or as required by panel size or branch breaker sizes.

2.2 PANELBOARDS IN GENERAL

- A. Provide panelboards consisting of an assembly of branch circuit switching and protective devices (circuit breakers, switch and fuse units, or combination thereof) mounted inside a dead front enclosure. Provide the number and size of these branch circuit devices as indicated by the circuiting, on the drawings, and in the schedules.
- B. Provide the following modifications and additional equipment as shown on the Drawings.
 1. Main circuit breakers.
 2. Shunt trip circuit breakers.
 3. Split buses.
 4. Integral remote control switches.
 5. Subfeed switches.
 6. Panelboard integral mounted relays and contactors.
 7. Feed through or sub feed lugs and/or bus.

8. Feed through cabling arrangement.
9. Double lugs for multiple cables or for future provisions.
10. Circumferential compression lugs where aluminum conductors are employed.
11. Ground fault interrupting circuit breakers.
12. Where main breakers are indicated, they shall be factory mounted to the bus and shall be located at top center panel. Back connected branch circuit breakers are not acceptable as main breakers.

C. Interiors

1. Rigid removable assembly of copper bus bars and interchangeable bolted branch circuit devices.
2. Bus bars drilled to permit branch circuit devices of all sizes and number of poles to be interchangeable and installed in any spare space of sufficient size, without disturbing adjacent units; without removing main bus or branch circuit connectors and without machining, drilling, or tapping in the field.
3. Arrange bus in sequence or distributed phasing so that multi-pole circuit breaker can replace any group of single circuit breakers of the same size.
4. Provide 100% rated neutral bus in each panelboard.
5. Provide ground bus in each panelboard.
6. Provide a non-linear rated panelboard when feed from a K-rated transformer.
7. Provide an isolated ground bus when panelboard feeds isolated ground receptacles.
8. Provide feed through and/or sub feed interiors as indicated on the panel schedules and one line diagram.

D. Enclosure

1. Code gauge steel box galvanized.
2. Provide a bolt-on ground connector to inside of enclosure.
3. Flush mounted in finished areas and where indicated. Surface mount elsewhere.
4. All panelboards installed outdoors or shall have a NEMA 3R enclosure.

E. Front

1. Doors must be provided on all lighting and power panels. Provide hinged door-in-door construction.
2. Heavy code gauge steel as required to maintain panel face flat.
3. Hold front closed with latch and lock.

4. Factory finished in ANSI 61 gray enamel or two coats of air-drying lacquer over a rust inhibitor.
5. Provide directory for total number of poles.
6. Provide approved lock. All panels keyed alike. Furnish four (4) sets matching keys and one key per panel to the Owner.
7. Welded angle rest at the bottom of the door to facilitate cover installation.
8. Doors over 48" in height shall have auxiliary fasteners at top and bottom of door in addition to lock and catch.
9. No commercial logo on face of equipment.

F. Terminal Lugs

1. Bolted type, labeled for either copper or aluminum conductors.
2. Locate main lugs properly at top or bottom, depending where main feeder enters.

G. Electrical Ratings

1. Panelboards are to be rated 120/208 volts or 277/480 volts, 3-phase, 4-wire, full neutral with ampacities as indicated on the Drawings (unless otherwise noted).
2. Short circuit withstand ratings shall be as indicated on the Drawings.
3. Where indicated, provide panelboards having a "service entrance" Type UL label with neutral bus factory bonded to frame or enclosure.

H. Circuit Breaker Devices

1. Plastic molded case. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time delay characteristics. Single-handle and common tripping multi-pole breakers.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Panelboard must be of the type which will accept the field installation of shunt trip devices of 60 amperes or less on the branch devices.
5. Interrupting capacities shall be as indicated on the Drawings. In general, 120/208 volt devices shall not be less than (10,000 AIC) and 277/480 not less than (14,000 AIC).
6. For lighting circuits that are controlled at panel, provide devices labeled "SWD" for switching purposes.
7. Bolted type terminals UL listed for either aluminum or copper 75EC cables.
8. Provide main breakers in panels served from transformers.

9. Locate next to each breaker or space unit an individual number.
 10. The use of series rated breakers shall be approved by the engineer prior to preparation of submittals.
- I. Ground fault interrupter branch circuit breakers shall be as indicated in panel schedules. Circuit breakers shall be circuit interrupting which will operate manually for normal switching functions and automatically under overload, short circuit, and 0.005 amp line-to-ground fault conditions. The operating mechanism shall be entirely trip-free so that contact cannot be held closed against an abnormal overcurrent, short circuit, or ground fault condition. The device shall be bolt-on type with insulated case construction and shall be interchangeable with standard 1P breakers utilized in the panelboard.
- J. Switch and Fuse Devices
1. Quick-make, quick-break, dead-front type. Each switch a self-contained unit, externally operable from the front.
 2. Fuse and switch compartment interlocked to prevent access to the fuse compartment until switch is thrown to "OFF" position. Interlock intentionally releasable by externally applied tool to permit checking switch and fuses under load.
 3. Switch units interchangeable for replacement, without disturbing balance of distribution panelboard's operation.
 4. Switches are to reject fuses other than those specified.
 5. Provide Class R rejection type fuses as specified elsewhere.
 6. Provide spare fuses as specified elsewhere.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Mount panel 4 feet to panel center but with maximum height of six feet 6 inches to handle of topmost switching device.
- B. Mount surface type panels a minimum 1 inch off wall on channels.
- C. Where flush mounted, the fire integrity of the wall in which it is installed must be maintained.
- D. Neatly arrange branch circuit wires and tie together in each gutter with Thomas & Betts nylon "Ty-Raps", or approved equal at minimum 4 inch intervals.
- E. Plug all knockouts removed and not utilized.

3.2 TOUCH UP AND CLEANING

- A. Vacuum all backboxes clean of debris after installation and prior to final acceptance.
- B. Touch up scratch marks, etc., with matching paint.

3.3 HOUSEKEEPING PADS

- A. Provide a 3-inch high reinforced concrete pad beneath all floor mounted panelboards.

END OF SECTION 16160

SECTION 16170 - DISCONNECT SWITCHES AND ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide disconnect switches and enclosed circuit breakers in accordance with the Contract Documents.
- B. Related Work Specified Elsewhere
 - 1. Setting motors and other equipment.
 - 2. Identification.
 - 3. Mounting heights.

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest provisions and latest recommendations of the following:
 - 1. UL Standards 98 and 508
 - 2. NEMA Standard KS1
 - 3. NEMA Standard AB1

1.3 SUBMITTALS

- A. Refer to Section 16035 concerning the procedures and additional document for submittals.

PART 2 - PRODUCTS

2.1 SAFETY SWITCHES

- A. Heavy-duty, single-throw knife switch with quick-make, quick-break mechanism, capable of full load operations. Meet NEMA and U.S. Government specifications for Class A switches.
- B. Provide with contact arc-quenching devices, such as magnetic blowouts or snuffing plates. Provide self-aligning switchblades with silver alloy contact areas and designed so that arcing upon making and breaking does not occur on the final contact surfaces. Provide with high-pressure, spring-loaded contact. Mount switch parts on high-grade insulating base.
- C. Enclosure: NEMA 1 with hinged door, and defeatable interlock when switch is in "On" position and can be positively padlocked in "On" and "Off positions. Utilize NEMA 3R (rain-tight) enclosures for exterior installations.
- D. Size, fusing and number of poles as shown or as required. Where fused, the devices must be provided with UL listed rejection feature to reject all but Class R fuses. Provide horsepower rated switch to match motor load if no size is shown. Use 3 pole plus solid neutral switches on four wire circuits and 3-pole switches on all other circuits, unless otherwise noted.

- E. Lugs must be UL listed for the type conductors used and be front removable.
- F. Provide six (6) pole switches for connection to motors with the following starter types:
 - 1. Non-reversing - two step - part winding - star connected.
 - 2. Non-reversing - full voltage - two speed separate winding.
 - 3. Non-reversing - full voltage - two speed single winding.
 - 4. Where otherwise noted.
- G. Heavy-duty, molded case circuit breaker capable of full load operations. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible. Circuit breaker shall include a stunt trip coil where indicated on drawings.
- H. Manufacturer to be the same as that for motor controllers, transformers, switchgear, etc.

2.2 TOGGLE TYPE DISCONNECT SWITCHES

- A. Provide switches that operate at their full rating with fluorescent, tungsten, and resistance loads - and at 80% of their rated capacity with motor loads.
- B. Switches to be heavy duty and have:
 - 1. Arc-resisting bodies.
 - 2. Slow make-and-break mechanisms.
 - 3. Silver alloy contact buttons.
 - 4. Side or back wiring with up to 10 AWG solid conductors.
- C. Acceptable manufacturers: Square D Class 2510, 11 or 12, or approved equal by Cutler-Hammer, Siemens or General Electric.

2.3 ENCLOSED CIRCUIT BREAKERS

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 - 3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
 6. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.
 7. Molded-Case Switch: Molded-case circuit breaker without trip units.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system.
 5. Shunt Trip: 120-V trip coil energized from separate circuit, rated for continuous duty.
 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage.
 7. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.4 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
1. Outdoor Locations: NEMA 250, Type 3R.
 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 FACTORY FINISHES

- A. Manufacturer's standard prime-coat finish ready for field painting.
- B. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before

shipping.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Each motor over 1/2 HP shall be provided with a horsepower-rated safety-type disconnect switch.
- B. Each piece of equipment utilizing multi-phase power shall be supplied with a safety-type disconnect switch or enclosed circuit breaker.
- C. Each piece of equipment utilizing single-phase power but protected at over 30 amperes shall be supplied with a safety-type disconnect switch.
- D. Equipment other than that mentioned above utilizing a toggle type manual control switch properly sized and rated for the equipment it serves.
- E. Factory installed disconnect switches or circuit breakers may be used to satisfy the above requirements with the Architect/Engineer's prior approval.

3.2 MOUNTING

- A. Provide connections and wiring to and from each disconnect switch and enclosed circuit breaker. Support conduit feeder from ceiling or floor.
- B. Disconnect switches and enclosed circuit breakers shall be mounted on adjacent wall or from the floor with independent supports. Switches and enclosed circuit breakers shall not be mounted on exhaust fan housings.

END OF SECTION 16170

SECTION 16399 - TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)
DISTRIBUTION PANELBOARD (INTEGRALLY MOUNTED)

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide Distribution Panelboard Transient Voltage Surge Suppressor in accordance with the Contract Documents.
- B. Related Work specified in Division 16000.
 - 1. Reviews and Acceptances - Section 16035.
 - 2. Identification - Section 16060.
 - 3. Panelboards - Section 16160.
 - 4. Grounding Systems - Section 16450.
- C. Related Work specified in other Divisions of these specifications.
 - 1. Concrete Housekeeping Pads.

1.2 SUMMARY

- A. This specification describes the electrical and mechanical requirements for Transient Voltage Surge Suppression (TVSS) and a sine wave tracking filter system integral to a distribution panelboard. Reference specification section 16160 for panelboard requirements. The specified system shall provide high energy surge suppression and sine wave tracking for electrical line noise attenuation. The unit shall be suitable for application in ANSI/IEEE C62.41 categories A, B and C environments as tested to ANSI/IEEE C62.45 and MIL-STD-220A.

1.3 STANDARDS

- A. The specified system shall be designed, manufactured, tested and installed in compliance with:
 - American National Standards Institute
 - Institute of Electrical and Electronic Engineers (ANSI/IEEE C62.11, C62.41, and C62.45)
 - Federal Information Processing Standards Publication 94 (FIP PUB 94)
 - Federal Specification (W-P-115b, c and W-C-375a, b)
 - National Electrical Manufacturer Association (NEMA) AB-1, PB-1, PB-1.1, and PB-2.2, LS-1
 - National Fire Protection Association (NFPA 20, 70, 75 and 780)
 - Underwriters Laboratories (UL 1449, UL 1283, UL 67)
 - MIL-STD-220A

1.4 SYSTEM DESCRIPTION

A. Environmental Requirements

1. Storage Temperature:

- a. Storage temperature range shall be -55 to +85 C (-67 to +187 F).

2. Operating Temperature:

- a. Operating temperature range shall be -40 to +50 C (-40 to +122 F).

3. Relative Humidity:

- a. Operation shall be reliable in an environment with 0% to 95% non-condensing relative humidity.

4. Audible Noise:

- a. The unit shall not generate any appreciable audible noise.

5. Magnetic Fields:

- a. The unit shall not generate any appreciable magnetic fields and shall be suitable for use directly inside computer rooms.

6. Operating Altitude:

- a. The system shall be capable of operating up to an altitude of 8000 feet above sea level.

B. Electrical Requirements

System Operating Voltage

The nominal system operating voltage shall be:
277/480 VAC (three phase WYE, 4 wire plus ground)

C. Integral Transient Voltage Surge Suppressor Requirements

1. Maximum Continuous Operating Voltage (MCOV):

- a. The TVSS maximum continuous operating voltage shall be greater than 115% of the nominal system operating voltage to ensure the ability of the system to withstand temporary RMS overvoltage (swell) conditions.

2. Operating Frequency:

- a. The operating frequency range of the system shall be at least 47 to 63 Hertz.

3. *Overcurrent Protection (fusing):
 - a. All protection modes (including Neutral to Ground) of the TVSS shall be internally fused at the component level with the fuses I²T capability to allow the suppressor's maximum rated transient current to pass through the suppressor without fuse operation. If the rated I²T characteristic of the fusing is exceeded, the fusing shall be capable of opening in less than one millisecond and clear both high and low impedance fault conditions. The fusing shall be capable of interrupting up to 300 KA symmetrical fault current with 600 VAC applied. This overcurrent protection circuit shall be monitored and provide indication of suppression failure/operability. Conductor level fuses or circuit breakers internal or external to the TVSS shall not be acceptable.

4. Protection Modes:
 - a. The TVSS shall provide protection as follows:

L-N, L-G, N-G: WYE connected systems
L-L, L-G: Delta connected systems

Note: L = Line, G = Ground, N = Neutral

5. Surge Current Capacity:
 - a. The surge current capacity based on ANSI/IEEE C62.41-1991 category C, 10KA, 8x20 μs current wave form, shall be as follows:

Line to Neutral	50,000 amps
Line to Ground	50,000 amps
Neutral to Ground	50,000 amps
Per phase	100,000 amps

6. * UL 1449 Ratings:
 - a. The TVSS performance ratings shall be based on the UL 1449 listed surge ratings for IEEE C62.41 category B3 impulse waveforms of 6KV 1.2 x 50 microseconds, 3KA 8 x 20 microsecond waveshapes. The maximum UL 1449 listed surge rating for each and/or all of the specified protection modes shall not exceed:

800 Volts Line to Neutral, Line to Ground and Neutral to Ground; and
1500 Volts Line to Line for 277/480 volt systems.

7. Joule Rating:
 - a. The TVSS system shall provide a joule rating that meets or exceeds the requirements of ANSI/IEEE C62.41 Category C delivery capability.

8. * Noise Attenuation:

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- a. The TVSS/Filter unit shall provide noise attenuation for electrical line noise of 50 dB (at 100 kHz) per 50 ohm measurement method with a frequency range of 10 kHz to 100 MHz. The unit shall be complimentary listed to UL 1283. Only UL 1283 complimentary listed products will be acceptable for this requirement all others shall be rejected.

9. Response Time:

- a. Typical response time of all suppression components shall be 0.5 nanoseconds.

10. Life Expectancy Testing:

- a. The unit shall be cable of protecting against and surviving at least 1250 10KA surges per ANSI/IEEE C62.41-1991 Category C without failing or degrading the UL 1449 surge suppression ratings by more than 10%.

D. Documentation

1. Equipment Manual:

- a. The manufacturer shall furnish an installation, maintenance and operation instructions for the specified unit.

2. Drawings:

- a. The manufacturer shall provide customer outline drawings that show unit dimensions, mounting and electrical connection details.

3. * UL 1449 Ratings:

- a. Documentation of the specified integral TVSS/Filter's UL 1449 Listing and the TVSS clamping voltage ratings shall be included as required product data submittal information.

4. * UL 1283 Complimentary Listing:

- a. Documentation of the specified integral TVSS/Filter's UL 1283 complimentary listing shall be included as required product data submittal information.

E. Warranty

- 1. The manufacture shall provide a full 5 year parts and labor warranty from date of initial operation against failure when installed in compliance with the above codes and the unit installation instructions.

F. Quality Assurance

- 1. The specified system shall be thoroughly factory tested before shipment. Testing of each system shall include but shall not be limited to quality control checks, dielectric voltage

withstand tests at twice rated voltage plus 1000 volts per UL requirements, and operational and calibration tests.

2. The unit shall be designed and manufactured in the USA by a qualified manufacturer of power conditioning equipment and active tracking filters. The manufacturer shall have been engaged in the design and manufacturer of such products for a minimum of 10 years.
3. Maximum Continuous Operating Voltage (MCOV) Testing:
 - a. The unit shall be factory tested to assure proper MCOV of the MOV.
4. Panelboards:
 - a. The TVSS shall be capable of being installed in Westinghouse, General Electric and Square D panelboards.

PART 2 - PRODUCT

2.1 INTEGRAL SURGE SUPPRESSION COMPONENTS

- A. The TVSS/Filter shall be constructed using multiple surge current diversion arrays of metal oxide varistors (MOV), matched to 1% variance, each rated for at least 50KA and 10 surges at 25KA capacity based on the standard 8x20 microsecond waveform. Each array shall be capable of withstanding over 1,250 pulses of the 10KA IEEE 62.41 Category C surge currents without failure when tested per C62.11, C62.45, suggested wait times. The array shall consist of multiple gap-less metal oxide varistors, with each MOV individually fused. The arrays shall be designed and constructed in a manner which ensures MOV surge current sharing. No gas tubes, silicon avalanche diodes or selenium plates/rectifiers shall be used. The status of each array shall be continuously monitored and a green LED shall be illuminated if the array is in full working order. All protection modes, including N-G, shall be monitored and internally fused, for compliance to NEC article 110.9, 110.10 and 280.22.
- B. Listings:
 1. The entire panelboard system inclusive of the integral TVSS/Filter shall be UL 67 listed and labeled as a whole by Underwriters Laboratories. The integral TVSS/Filter unit shall be UL 1449 and UL 1283 recognized by Underwriters Laboratories when installed in the panelboard. The TVSS unit shall have the UL 1449 ratings on its label.
 2. Identification and Labeling:
 - a. The TVSS shall be UL 1449 recognized when installed integral to a panelboard. Its UL suppression ratings per mode and the unit's model number shall be appropriately labeled on the unit. The entire panelboard shall be listed and labeled to UL 67.
 3. Status Indication:
 - a. Red and green solid state indicators with printed labels shall be provided on the front cover to repeatedly indicate unit module status. The absence of the green light

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and the presence of the red light shall reliably indicate that one or more surge current diversion arrays has failed and that service is needed to restore full operation. Additionally, electrically isolated form C (one N.O. and one N.C.) summary alarm contact rated for at least 120 VAC and 1 ampere shall be provided for remote annunciation of the unit's status. The summary alarm contact shall change state if any one or more of the surge current diversion arrays has failed.

4. Phase Loss Detection:

- a. The TVSS shall be equipped with phase loss, under voltage (-30% typical) and power loss detection circuits. The monitor circuits shall be connected to the form C summary alarm contacts for remote monitoring.

C. Accessories

1. Audible Alarm:

- a. The specified system shall be equipped with an audible alarm which shall be activated when any one or more of the surge current diversion modules has failed. In conjunction with the audible alarm, an alarm on/off switch shall be provided to silence the alarm and an alarm push-to-test switch shall be provided to test the alarm function. Both switches and the audible alarm shall be located on the unit's hinged front cover.

2. Transient Counter:

- a. A transient voltage surge counter shall be included to totalize transient voltage surges which deviate from the sine wave envelope by more than 125 volts. The readout shall be at least a six digit LCD located on the unit's hinged front cover. The counter shall be equipped with a battery back-up to retain memory when power is not present. A pushbutton switch on the display's face-plate shall be provided for manual counter reset.

3. Remote Monitor panel:

- a. A self-contained, UL listed, monitoring panel shall be available to allow remote annunciation of the system status. Input power to the monitoring panel shall be equipped with a 6 foot long input power cord with a NEMA 5-15 plug. The monitor panel shall have an audible alarm, red and green LED's an alarm on/off switch to silence, and a push-to-test alarm switch. The monitor panel shall connect to a specified surge suppression system by way of a two wire control cable. Under normal operation the green LED shall be illuminated. Upon correction or module failure, the monitor panel shall automatically reset to the normal mode. The panel shall be a non-conductive enclosure.

PART 3 - INSTALLATION

3.1 GENERAL

- A. See panelboard specification section 16160 for installation requirements.
- B. The contractor and panelboard manufacturer shall comply with the TVSS manufacturers recommended installation practices and shall comply with all applicable codes.

END OF SECTION 16399

SECTION 16440 – SWITCHBOARDS

PART 1 GENERAL

1.1 DESCRIPTION

- A. General: Provide service distribution switchboards in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000:
 - 1. General Electrical Provisions (Equipment Supports) - Section 16010.
 - 2. Identification - Section 16060.
 - 3. Grounding Systems - Section 16450.
- C. Related Work Specified in Other Divisions of these Specifications:
 - 1. Concrete housekeeping pads.

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. Ground fault protection: UL Standard 1053.
 - 2. Switchboards: NEMA Standard PB2 and UL Standard 891.
 - 3. Switches: UL Standard 98 and NEMA Standard KS1.
 - 4. Switches and circuit breakers: NEMA Standard AB1.
 - 5. Bolted pressure switches: UL 977.
 - 6. Meters: ANSI Specification C 39.1.
- B. All sections and devices shall be UL listed and labeled.

1.3 SUBMITTALS

- A. With each switchboard acceptance drawing, the following is required.
 - 1. Refer to Section 16035 concerning the procedure and additional documents for submittals in concert with switchboard submittals.
 - 2. Include fully detailed and dimensioned plans, section and elevations. Include information on type and size of structural supports, metal thicknesses, surface finishes, bus cross sections, provisions for lifting as well as single line diagram of circuit breakers, switches, bus arrangements, metering arrangements, etc.

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3. Furnish a complete schematic wiring diagrams and a full set of equipment wiring diagrams for protective equipment relays, over, pilot lights, alarms, controls, etc. Provide narratives for all wiring diagrams.
4. All fuse sizes and types must be indicated.
5. All nameplate information must be complete.
6. All mimic bus arrangements must be illustrated.

1.4 QUALITY ASSURANCE

- A. Each switchboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short-circuit rating shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such ratings shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to each switchboard. Test data shall be submitted to the Engineer at time of submission of Acceptance Drawings.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

- A. The switchboard manufacturer shall be represented by a local service or organization, available on a 24-hour per day basis fully capable of providing service on all equipment including all O.E.M. equipment. Equipment shall be Square D QED-S POWER-STYLE or approved equal by Cutler-Hammer, General Electric, or Siemens.

2.2 GENERAL

- A. Provide switchboards of the free standing, totally enclosed dead-front safety type, consisting of an assembly of circuit breakers and/or switches of the number, size and arrangement shown on the Drawings.
- B. Carefully check the physical space limitations for each switchboard and furnish switchboards to match those conditions. Nothing in these Specifications shall preclude the use of a custom designed switchboard (as approved by the Engineer) to meet those limitations. Custom designed switchboard must meet all applicable UL and NEMA requirements and shall carry a UL label.
- C. Provide service entrance label where required.
- D. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90" high. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure. The frame structure members shall be die-formed 12-gage steel bolted together and reinforced at corners with rugged gussets internal and external to the structure members. The switchboard frame is to be suitable for use as floor sill in indoor installations.
- E. The switchboard, circuit breakers, switches, and bussing shall be fully rated for the available fault current shown on the Drawings.

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- F. Switchboard shall include protective devices listed on the Drawings and as specified with necessary interconnection, instrumentation and control wiring.
- G. Switchboard shall be front- connected, front-accessible unless noted otherwise on the Drawings.
- H. Feeder devices shall be group-mounted. The operating handle, lever, etc., of each device shall be externally accessible without opening or removal of covers except where a door is furnished over the panel. Provide hinged front panels to allow internal access to circuit breakers, switches, metering, accessories, and blank compartments.
- I. Main, sub-main and tie devices shall be individually-mounted.
- J. Utility Metering Compartment: Fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- K. All vertical sections comprising the switchboard shall be front and rear-aligned without exception.
- L. Provide barriers between adjacent switchboard sections.
- M. All steel surfaces shall be chemically cleaned and treated, providing a bond between paint and metal surfaces. The switchboard exterior shall have a factory-applied finish in the manufacturer's standard gray color over a rust-inhibiting primer. The undersurfaces of outdoor units shall be additionally treated with a corrosion-resistant undercoating.
- N. Control wiring, necessary fuse blocks and terminal blocks within the switchboard are to be furnished when required. All control wires leaving the switchboard are to be provided with terminal blocks with suitable numbering strips.
- O. All hardware used on conductors shall have a high tensile strength, and a suitable protective finish.
- P. Switchboard shall be provided with adequate lifting means, and be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floors sills.
- Q. Switchboards installed outdoors shall have a NEMA 3R enclosure.

2.3 PULL BOX OVER SWITCHBOARD

- A. Where required for conduit terminations, provide a pull box of same type of construction and finish as the switchboard with the following features:
 - 1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
 - 2. Removable covers shall from top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
 - 3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
 - 4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

2.4 BUSES

- A. Buses shall be arranged throughout A-B-C left to right, top to bottom, and front to rear. Where special circuiting precludes this arrangement (as accepted by the Architect/Engineer) buses shall be permanently labeled.
- B. Bus material shall be copper or tin-plated aluminum.
- C. Buses shall be uniform capacity for full length of switchboard's main and distribution sections. Tapered buses are not permitted. Provide bolt holes drilled and tapped for future extension at both ends of buses, including neutral and ground buses. The provisions shall include buses installed and extended to the extreme side of the section and be fabricated in such a fashion that the addition of a future section would require only the installation of standard bolted splice plates.
- D. Provide insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- E. All buses shall be rigidly braced to comply with the integrated equipment rating of the switchboard.
- F. A ground bus shall be furnished secured to each vertical section structure, and shall extend the entire length of the switchboard. The ground bus shall be rated at least 33 percent of the ampacity of the phase busses, unless otherwise indicated on the Drawings.
- G. The neutral bus shall be rated for 100 percent of the ampacity of the phase buses, unless otherwise indicated on the Drawings. The neutral bus in the feeder sections shall not be located more than 20 inches from the front of the switchboard.
- H. Each switchboard distribution section shall be fully bussed.

2.5 FEEDER INSTALLATION AND TERMINATION

- A. Group cables paralleling one another and arranged so as to permit easy insertion of a clamp-on Ammeter on each cable.
- B. All line and load side conductors emanating from the top of bottom of the switchboards shall be lashed to cable braces provided in the switchboard. Lashing shall be performed as per the manufacturer's recommendations to maintain the integrated equipment rating. Lashing material shall be non-metallic fire and heat resistant with a tensile strength of 2,000 pounds. In general on service entrance cable run and bend the cable in such a manner so as to rest directly against the cable braces. Make six (6) revolutions around the "A" and "B" phase and the six (6) revolutions around the "B" and "C" phase cables. With the remaining lashing material make four (4) to five (5) revolutions between each of the phase cable tying a knot to the cable braces as the last revolution is complete. All revolutions must be as tight as possible to prevent magnetic stress during short circuits. Load cables in general should be lashed with four (4) revolutions around the cable and the brace, then tied in a knot after the last revolution.
- C. Where bus ducts terminate at switchboards, these conductors (including neutral and grounds) shall be extended to the switchboard bus. The use of cable is unacceptable.

2.6 CIRCUIT BREAKERS

- A. General:

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1. Circuit breakers shall be listed by Underwriters Laboratories and conform to applicable requirements of NEMA standard AB1, and appropriate classification of Federal Specification W-C-375. The circuit breaker shall be completely enclosed in a molded case or insulated case as required.
 2. The operating mechanism shall be quick make, quick break, and trip free to prevent holding the circuit breaker contacts closed against a fault or abnormal sustained overload. The circuit breakers shall have a common trip bar so that a fault on one pole opens all poles. When tripped, the handle shall assume a position between on and off. The circuit breakers shall have thermal magnetic trip units that provide inverse time delay (overload and instantaneous) short circuit protection. The inverse time delay shall be ambient compensated for circuit breaker ambient temperatures of 10-50°C. It will have approximately the same tripping characteristics throughout this temperature range.
 3. The circuit breakers shall be rated to carry 100% of their ampere rating intermittently and 80% continuously. The ampere and voltage shall be as shown on the Drawings.
- B. Main Circuit Breakers, Tie Breakers and Feeder Circuit Breakers, 1000 amps and above.
1. Circuit breakers shall be Square D POWERPACT, or approved equal.
 2. Breaker shall contain a Square D MICROLOGIC 5.0 electronic trip unit with true RMS sensing and interchangeable rating plug with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
- C. Main Circuit Breakers, Tie Breakers and Feeder Circuit Breakers, 250 amps to 900 amps.
1. Circuit breakers shall be thermal-magnetic, molded case with adjustable magnetic trip setting.
- D. Feeder Circuit Breakers, 225 amps and below
1. Circuit breakers shall be thermal-magnetic, molded case.

2.7 BOLTED PRESSURE SWITCHES

- A. Application: Switches 800 amps and above.
- B. Equipment shall be Square D, or approved equal by Pringle, Cutler-Hammer, Boltswitch, or Siemens.
- C. Manually operated dead front, totally enclosed. Interlock to prevent access to closed switch. Handle shall be capable of being padlocked in the "off" position.
- D. Main Contact Interrupting Capability: Twelve times the switch current rating, minimum.
- E. Operating mechanism uses a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts.

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- F. Ground-Fault Relay: Self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
- G. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

2.8 FEEDER SWITCHES

- A. Application: Switches 600 amps and below.
- B. Manually operated, heavy duty, quick-make, quick-break, dead-front type. Each switch shall be a self-contained unit, externally operated from the front. Interlock to prevent access to closed switch. Handle shall be capable of being padlocked in the "off" position.
- C. Switches shall be equipped with fuse clips suitable for the fuses indicated on the Drawings.

2.9 GROUND FAULT PROTECTION

- A. Provide ground fault protection on all disconnect switches and circuit breakers rated 1000 amps or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase.
- B. Provide a zero sequence type ground fault system including current sensor and appropriate relaying equipment. The current sensor shall enclose all phase (and neutral, if present) conductors to be monitored. The current sensor frame shall be so constructed that one leg can be opened to allow the removal of the sensor without disturbing the cables or requiring drop-links in the bussing. A test winding shall be provided to simulate the flow of ground fault current through the current sensor for testing.
- C. The ground fault relay shall be of solid state construction and have adjustable pick-up for ground fault currents from 100 amperes to 1200 amperes. The ground fault sensor shall continuously sense the output of the monitor. Should the sensor detect a ground current in excess of the pick-up setting for a duration exceeding the time delay, the relay shall shunt-trip the appropriate device and provide a visual indication that a ground fault has occurred.
- D. Direct adjustable time delay shall be provided by the ground fault relay circuitry and shall be from 0.1 to 0.3 seconds. The time delay shall be permanently calibrated to preclude tampering after installation.
- E. Each ground fault sensor shall be provided with a panel or display to test the ground fault system. The system shall be able to be tested with or without tripping the feeder switch/ circuit breaker. The test panel or display shall be installed in the front of the switchboard integral or adjacent to the protective device. The ground fault system shall meet the on-site testing requirements of NEC 230.95(C).

2.10 METERING

- A. Furnish, install and connect on each bus of the switchboard the following meters.
 - 1. One ammeter with current transformers to measure the current in each phase.
 - a. Ammeter shall have selector switch to select the phase being metered and an "off" position.

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- b. Ammeter shall register full load current at an approximately 3/4 full-scale deflection.
- 2. One voltmeter to measure all combinations of line-to-line.
 - a. Voltmeter shall have selector switch with "off" position to select voltage configurations A-B, B-C, and C-A and "off".
 - b. Voltmeter shall typically read the line-to-line voltage at not less than 3/4 full-scale deflection.
 - c. Current-limiting fuses shall be provided for the voltage connections.
 - d. Provide red line on meter at 480 and/or 208 volts as required.
- 3. All front plates used for mounting meters, selection switches or other front mounted devices shall be hinged with all wiring installed and laced with flexibility at the hinged side.

2.11 TVSS DEVICE

- A. IEEE/ANSI C62.41 and C62.45, integrally mounted, plug-in style, solid-state, parallel-connected, sine-wave tracking suppression and EMI/ RFI filtering modules.
- B. Minimum single-impulse current rating shall be as follows:
 - a. Line to Neutral: 200,000 A
 - b. Line to Ground: 200,000 A.
 - c. Neutral to Ground: 100,000 A.
- C. Protection modes shall be as follows:
 - a. Line to neutral.
 - b. Line to ground.
 - c. Neutral to ground.
- D. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.
- E. Category C combination wave clamping voltage shall not exceed 1000 V, line to neutral and line to ground on 277/480 V systems.
- F. UL 1449 clamping levels shall not exceed 800 V, line to neutral and line to ground on 277/480 V systems.
- G. Withstand Capabilities: 3000 Category C surges with less than 5 percent change in clamping voltage.
- H. Accessories shall include the following:
 - a. Form-C contacts, one normally open and one normally closed, for remote monitoring of system operation. Contacts to reverse position on failure of any surge diversion module.
 - b. Audible alarm activated on failure of any surge diversion module.
 - c. Six-digit transient-counter set to totalize transient surges that deviate from the sine-wave envelope by more than 125 V.

2.12 MIMIC BUS

- A. A simplified one line diagram of the switchboard shall be mounted above the main service disconnect. The one line shall show the main, all feeders and bussing. Any special operating instructions shall be described.
- B. The diagram shall be an engraved plate made of 1/8" thick phenolic laminated white core, black surface, dull finish with minimum 1/8" letters, and shall be attached with stainless steel screws.

PART 3 - EXECUTION

- 3.1 Install switchboards when the area is free and clear of dust and debris. Protect switchboards at the time from dust and moisture. Do not utilize switchboards for temporary lighting and power services.
- 3.2 Install switchboards on 3-inch high reinforced concrete housekeeping pads which shall follow the contour of switchboards with 3 inches clear all around. The Division 16 contractor shall provide the housekeeping pads.
- 3.3 Service entrance and incoming feeder conduits shall enter switchboard from bottom unless otherwise permitted by Engineer. Incoming bus duct shall enter the switchboard from the top.
- 3.4 At the completion of the work, each switchboard shall be field tested in accordance with Section 16065.
- 3.5 Set each ground fault sensor pick-up at 25 percent of the rating of the overcurrent protective device with a 0.1 second time delay unless otherwise indicated.
- 3.6 The person responsible for installing the electrical distribution system shall provide the building owner with a single line diagram of the record drawing for the electrical distribution system which includes the location of check-metering access, schematic diagram of non-HVAC electrical control systems, and electrical equipment manufacturer's operating and maintenance literature.

END OF SECTION 16440

SECTION 16450 - GROUNDING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide a low impedance grounding system in accordance with the Contract Documents.
- B. Related Work Specified in Division 16000
 - 1. Testing, Acceptances and Certification - Section 16065.
 - 2. Raceway and Boxes - Section 16110.
 - 3. Wire and Cable - Section 16120.
 - 4. TVSS - Section 16400
 - 5. Dry Type Transformers - Section 16470
 - 6. Luminaires and Accessories - Section 16500
 - 7. Low Voltage Systems - Section 16780.

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. UL Standard 467
 - 2. ANSI C1
 - 3. IEEE Standard 142
 - 4. National Electrical Safety Code.
 - 5. National Electrical Code.

1.3 SUBMITTALS

- A. Provide a complete set of shop drawings showing service grounding methods as called for on the construction documents.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Furnish and install an electrical grounding system as indicated on the construction documents and as specified herein.

- B. Grounding systems shall be installed in accordance with the requirements of the local authorities, NEC Section 250, and subject to the approval of the Architect/Engineer.
- C. All ground wires and bonding jumpers shall be stranded copper installed in conduit. All ground wires shall be without joints and splices over its entire length.

2.2 GROUNDING SYSTEMS

- A. The system neutral shall be grounded at the service entrance only and kept isolated from grounding systems throughout the facility.
- B. Each system of continuous metallic piping and ductwork shall be grounded in accordance with the requirements of the NEC Section 250.
- C. Bond each section of switchboard housing and service conduits entering switchboards to ground bus.
- D. PVC conduits and portions of metallic piping and duct systems which are isolated by flexible connections, insulated couplings, etc., shall be bonded to the equipment ground with a flexible bonding jumper, or separate grounding conductor.
- E. Mechanical equipment shall be bonded to the building equipment grounding system. This shall include but is not limited to, fans, pumps, chillers, etc.
- F. All raceways (metallic and nonmetallic) shall contain an equipment grounding conductor. Conductor shall be sized in accordance with NEC Table 250.122.
- G. Grounding electrode conductors shall be provided for separately derived systems and shall be connected to building steel, cold water pipes, or an alternate grounding means as listed in NEC 250.52.
- H. When building steel is not available and a metal underground water pipe in direct contact with the earth for 10 feet or more is not available, a grounding electrode conductor riser shall be installed for the dry type transformers. Riser to be sized based on NEC 250.66. The secondary conductors of the dry type transformers connected to each riser shall be added together to determine the grounding electrode size.
- I. Receptacles shall be grounded to the outlet box by means of a bonding jumper between the outlet box and the receptacle grounding terminal. Isolated ground receptacles, ground wire shall run back to service ground bus.
- J. Main telephone terminal board and riser terminal boards shall be grounded by installing a 6 AWG bare copper conductor riser between the building service ground and the last riser terminal board. At each terminal riser board provide one (1) three foot (3') 6 AWG bare copper conductor from the telephone riser ground and terminating at the riser terminal board.
- K. Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings and other metal noncurrent-carrying parts that are to serve as grounding conductors shall be effectively bonded where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings so designed as to make such removal unnecessary.
- L. Outdoor pad mount transformer enclosures shall be connected with 4 AWG bare copper conductor to 4/0 AWG bare copper conductor installed not less than 24 inches below grade, connecting to the indicated ground rods. Fence and equipment connections shall be 4 AWG bare copper. Fence shall be grounded at each gate post and corner post. Each gate section shall be bonded to the fence post

through a 1/8-inch by 1-inch flexible braided copper strap and approved clamps. Transformer neutral connections shall be a minimum 1/0 AWG copper. Where the rated secondary current exceeds 400 amperes, the size of the transformer neutral-ground connection shall be increased in size to not less than one-half the cross-section area of the secondary-phase conductors.

- M. Provide grounding type bushings for conduits terminated through multiple concentric knockouts not fully knocked out, on inside of panelboards. Ground bushing with 12 AWG bare copper conductor to panelboard ground bus.

2.3 SERVICE GROUNDING METHODS

- A. Ground rods shall be copper-clad steel not less than 3/4 inch in diameter, 10 feet long, driven full length into the earth. The maximum resistance shall not exceed 25 ohms. If this resistance cannot be obtained with a single rod, two additional rods shall be installed not less than 6 feet on center. If sectional type rods are used, two additional sections may be coupled and driven with the first rod.
- B. If available on the premises at each building or structure served, Items 1-4 below shall be bonded together to form the grounding electrode system:
 - 1. A metal underground water piping system used for grounding shall be in direct contact with the earth for ten feet or more and shall be electrically continuous. Provide bonding jumpers at water meter and at insulating joints.
 - 2. The metal frame of the building, where effectively grounded.
 - 3. Concrete-Encased Electrode. An electrode encased by at least 2 in. of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 20 ft of one or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 2 in. diameter, or consisting of at least 20 ft of bare copper conductor not smaller than 4 AWG.
 - 4. Ground Ring. A ground ring encircling the building or structure, in direct contact with the earth at a depth below earth surface not less than 2-1/2 ft, consisting of at least 20 ft of bare copper conductor not smaller than 2 AWG.
- C. Steel reinforcing bars used for grounding shall be encased by at least 2 inches of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth. Reinforcing bars shall be minimum 2 inch diameter and consisting of 20 feet of one or more steel reinforcing bars.
- D. All bonding jumpers for the above grounding systems shall be sized in accordance with NEC 250.66.

PART 3 – EXECUTION

3.1 GENERAL

- 1. Grounding connections and splices shall be brazed molded exothermic welded, bolted clamp terminal or pressure-connector type. Bolted connections and pressure-connectors shall be used for connections to removable equipment.
- 2. Provide a complete test in accordance with Section 16065 of these Specifications.

END OF SECTION 16450

SECTION 16470 - DRY TYPE TRANSFORMER

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: Provide dry type transformers in accordance with the Contract Documents.
- B. Related Work Specified Elsewhere
 - 1. Finish painting.
 - 2. Equipment Supports.

1.2 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the applicable provisions and recommendations of the National Electrical Manufacturer's Association.
 - 1. UL Standard 1561
 - 2. ANSI Standard C57.12.01
 - 3. NEMA Standard ST20

1.3 SUBMITTALS

- A. Shop Drawings: Submit shop drawings and manufacturer's data for each type and size dry transformer as indicated on the Drawings.

PART 2 - PRODUCTS

2.1 GENERAL

- A. The transformer shall be dry-type with kilovolt-ampere (KVA) rating shown, with delta-connected primary and wye-connected secondary, rated 480 volt-208/120 volt, three-phase.
- B. Insulation: All transformers rated 9 KVA and larger shall utilize 220°C UL approved insulation systems. Transformer temperature rise shall not exceed 150°C above a 40°C ambient under full load.
- C. Coils: Coil conductors to be continuous wound construction with terminations welded without auxiliary flux materials. Wind coils with copper or aluminum magnet wire, vacuum impregnated with non-hygroscopic, thermosetting varnish. Coils to be protected with an outer layer of glass tape or similar quality insulation. Provide each layer with end-fillers or tie-downs to ensure maximum mechanical strength. Brace tap terminations to magnet wire. Brace primary and secondary magnet wire directly to bus studs or lugs. Windings shall be continuous with no splices.
- D. Core

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1. Manufacture core from a high-grade, non-aging 29 gauge silicon steel with high magnetic permeabilities, low hysteresis and eddy current losses. Keep magnetic flux densities well below saturation to allow for a minimum of 10 percent over-voltage excitation.
 2. Cut laminations with the direction of the grain and free from burrs. All laminations must be core plated or annealed and firmly butted. The core laminations shall be clamped tightly and compressed to provide quiet operation and to prevent damage during shipment.
- A. Taps
1. Full-capacity taps shall be provided on the primary side of the transformer having two 2.5 percent above normal and four 2.5 percent below normal.
- B. Enclosures
1. Provide lifting brackets on all sizes.
 2. Ventilated openings shall be such as to avoid accidental access to live parts.
 3. Degrease, clean, phosphatize and paint the entire enclosure with one (1) coat of zinc chromate primer and two (2) coats of gray enamel.
- C. General
1. Enclosure temperature rise shall not exceed 35EC rise above ambient. The core and coil assembly shall be grounded to the enclosure by means of a flexible copper grounding strap of adequate size. Provide transformers up to and including 75 KVA suitable for floor, wall, or ceiling mounting. Transformers exceeding 75 KVA shall be floor mounted only.
- D. Sound Levels
1. The transformer shall operate at audible sound levels substantially below ANSI Standard C89.2. Sound levels shall not exceed 45 decibels (db) for 15- to 50-KVA units, 50 db for 51- to 150-KVA units, 55 db for 151- to 300-KVA units, and 60 db for 301- to 500-KVA units.
 2. Core and coil assemblies 30 KVA and larger to be mounted on rubber vibration isolators designed specifically to reduce 120 Hz sound and multiply harmonics.
- E. Acceptable Manufacturers: Square D, Siemens, General Electric, Cutler-Hammer, and Acme.

PART 3 - EXECUTION

3.1 GENERAL

- A. Resiliently suspend each dry-type transformer on double deflection neoprene in the shear hanger rod isolator assemblies, capable of providing minimum 3/8 inch static deflection.
- B. Provide grounding electrode conductor from transformer secondary to nearest building ground for each separately derived system. Grounding electrode conductor shall be sized in accordance with

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NEC Section 250.66 for the derived phase conductors. Install a ground riser as described in Section 16450 if building steel is not available or if an adequately grounded cold water piping system is not available.

- C. Provide a 3-inch high reinforced concrete pad beneath all floor mounted transformers.

END OF SECTION 16470

SECTION 16500 - LUMINAIRES AND ACCESSORIES

PART 1 – GENERAL

1.1 DESCRIPTION

A. General:

1. This Section specifies requirements for luminaires, lamps, ballasts, and accessories.
2. The Contractor shall be responsible for all luminaire quantities, lengths and clearances required and shall inform the Architect in writing, at the time the bid submission is made, of any discrepancies or variances found with fixtures or details specified herein or in the Luminaire Schedule and other Contract Documents.

B. Related Work Specified in Division 16000

1. Electrical General Provisions - Section 16010
2. Identification - Section 16060
3. Equipment Connections and Coordination - Section 16102
4. Raceways and Boxes - Section 16110
5. Wire and Cable - Section 16120
6. Wiring Devices - Section 16140
7. Grounding Systems - Section 16450

C. Related Work Specified in Other Divisions of these Specifications

1. Fixtures, furnishings, and equipment package

1.2 STANDARDS

A. Codes:

1. Luminaires, components, and installation shall be in accordance with the American National Standards Institute, the latest revision of the National Electrical Code (NEC) and any applicable federal, state, and local codes and regulations.
2. All lamps shall be in accordance with the Energy Policy Act of 1992 (Public Law #102-486).

B. UL Listing:

1. All luminaires, ballasts, transformers, and other electrical components shall be manufactured in strict accordance with the appropriate requirements of the Underwriter's Laboratories, Inc. and any others that may be applicable. The appropriate UL labels shall be affixed to all luminaires.

2. The Contractor shall be responsible for coordinating the characteristics and the appropriate UL labeling of all luminaires and their components with the ambient conditions which will exist when the luminaires are installed.

1.3 SUBMITTALS

A. Shop Drawings and Product Data Submittals

1. Submit shop drawings and product data in accordance with the requirements of the General Conditions and as described herein and elsewhere in the Contract Documents.
2. The Contractor shall submit data for approval of the Architect, detailed shop drawings and product data for all luminaires specified herein and elsewhere in the Contract Documents. No luminaire shall be installed without the approval of its shop drawings, product data and/or sample.
3. Shop drawings and product data shall indicate the name of the project, fixture type, manufacturer's name, luminaire catalog number and catalog numbers for lampholders, ballasts, diffusers, and internal protective components.
4. Prior to fabrication and submittal of the shop drawings and product data, the Contractor shall coordinate luminaires and conduit entries with equipment, ducts, pipes, openings, etc.
5. Submit Manufacturer's dimensioned and scaled shop drawings showing in complete detail the fabrication of all luminaires. These drawings shall include overall detail dimensions, finishes, materials, metal thicknesses, fabrication methods, support methods, ballasts, sockets, thicknesses of diffusers, types of reflectors, provisions for relamping, and all other pertinent information, to show compliance with all Contract Documents.
6. Custom luminaire fabrication details shall be drawn at either full size or half-size scale. Fixture fabrication details shall illustrate a minimum of three (3) critical views indicating all fabrication and assembly methods, materials, and materials' gauges and finishes.
7. Where luminaires are mounted in continuous rows or in architectural coves, shop drawings shall indicate exact luminaire locations, layout, connecting components, coupling plates, changes in elevation, corner details, assembly methods, and reinforced concrete base details.
8. Submit product data which includes luminaire type, luminaire illustration with mounting details, luminaires certification of suitability for use in locations indicated, and photometric test reports which include the following:
 - a. Complete candlepower summary with graphical and numerical data in 5 degree increments for up and down quadrants and at 22-1/2 degree azimuth increments including normal and parallel.
 - b. Visual comfort probability data
 - c. Coefficients of utilization data
 - d. Luminaire efficiency
 - e. Lamp description
 - f. Lamp lumen output

g. Zonal lumens and percentages

B. Samples

1. Upon request, submit samples of custom luminaires, modified luminaires, and substitution items for the purpose of ascertaining photometric performance, quality of visible parts and details, maintenance features, methods of installation, and safety features. These samples shall be submitted for approval at no expense to the Owner, with all transportation prepaid. The samples will be returned to the Contractor after the reviews are completed at the expense of the Contractor.

A. Schedule

1. Submit a typewritten list of luminaires indicating the type, general description, manufacturer with address and telephone number, catalog number, applied voltage, ballast type, lamp type, and luminaire quantities.
2. Submit a maintenance and operation schedule and describe tools required, types of cleaners to be used, and replacement parts.
3. Upon request furnish for review by the Architect an itemized schedule of unit equipment costs for all luminaire types to be provided under the Contract.

PART 2 – PRODUCTS

2.1 GENERAL LUMINAIRE DESIGN AND CONSTRUCTION

- A. Manufacture luminaires to the specifications described above, hereafter, and as indicated in the Luminaire Schedule and all Contract Documents. Acceptable manufacturers are listed in the Luminaire Schedule shown on the Drawings.
- B. Provide proper thickness of code gauge sheet steel so that all luminaires are rigid, stable, and will resist deflection, twisting and warping under normal installation procedures, relamping, and maintenance.
- C. All luminaire designs shall include, as applicable, plaster frames, trim rings, shrouds, flanges, backboxes, support hardware, and any other components required for proper installation of the luminaires.
- D. Luminaires with covers, cones, or diffuser frames, which are to be mounted above twelve feet from the finished floor level, shall be provided with safety chains or other acceptable backup means of support to properly secure such items to main housing.
- E. Rows of luminaires shall be designed with concealed splice plates and shall be free of light leaks. Components such as reflectors, trims, diffusers and other visible items shall be properly aligned with no overlaps, gaps, or other imperfections.
- F. All continuous linear luminaires shall be fabricated with the longest lengths consistent with the Contract Documents and with shipping and installation constraints. If the lengths are shorter than those designated on the Drawings, the Contractor shall specifically inform the Architect in the shop drawings prior to ordering the luminaire.

- G. The Contractor shall coordinate and detail all necessary structural supports and support hardware required by the NEC for the safe attachment of all luminaires to mounting surfaces.
- H. All luminaires shall be designed for installation and proper operation in the actual ventilation and temperature conditions in which the luminaires are installed.
- I. Provide neoprene gasketing, stops, and barriers where required to prevent light leak and/or water and water vapor penetrations. Enclosed luminaires installed in the following locations shall have neoprene gasketing:
 - 1. Locker rooms
 - 2. Aquatic areas
 - 3. Aquatic mechanical equipment rooms
 - 4. Exterior
- J. Provide finished product with smooth clean ground metal edges, trims, and frames as well as tight fitting connections, hinges, and closures.
- K. Provide access for servicing the installed luminaire and for replacement of electrical parts without removal or disassembly of the luminaire.
- L. Unless otherwise noted, provide emergency battery packs, emergency quartz restrike, or stand-by systems as required for luminaires connected to emergency circuits.
- M. High intensity discharge luminaires, connected to emergency circuits, shall be provided with a quartz restrike or stand-by system which is activated during loss of power.
- N. High intensity discharge luminaires shall be completely enclosed, unless otherwise noted.
- O. Where acrylic is used for lenses, refractors, and diffusers with luminaires with H.I.D. sources, the luminaires shall be designed not to exceed a 65°C luminaire ambient temperature.
- P. All incandescent luminaires supplied for recessing in suspended ceiling shall be supplied with prewired junction boxes.
- Q. Luminaire doors shall be provided as follows: Positive light seal, concealed safety hinges, and inconspicuous "positive spring loaded" holding latches, which are hingeable from either side and operable without the use of tools.
- R. Where luminaires are mounted in tandem in continuous uplight or downlight coves, the Contractor shall field coordinate fixture quantity and length required to provide a continuous band of light without gaps to within 6" of row ends.

2.2 RECESSED LUMINAIRES

- A. Recessed luminaires shall be of a type which coordinate properly with the ceiling construction in which they are to be mounted. Discrepancies between luminaire catalog references appearing in the Contract Documents and actual construction into which they are to be installed shall be brought to the attention of the Architect prior to the submission of shop drawings.
- B. Any ferrous parts and supports, other than parts manufactured of stainless steel, shall be completely rustproofed after fabrication, and prior to the application of finish coatings. Rustproofing shall be by means of galvanizing, bonderizing, zinc plating, or by treatment with other industry standard rust

preventing process that provide rustproofing qualities equal to the processes mentioned.

- C. All screws, bolts, nuts, and other fastening and latching hardware shall be cadmium or equivalent plated.
- D. All recessed luminaires shall be provided with approved thermal protection devices to deactivate the luminaire in case of excessive heat build-up.

2.3 PENDANT AND SURFACE MOUNTED LUMINAIRES

- A. Pendant or surface mounted luminaires shall be provided with required mounting devices and accessories, including hickey, stud-extensions, ball-aligners, canopies and stems. Locations of luminaires in mechanical areas shall be coordinated with the Mechanical Contractor. Mounting stems of pendant luminaires shall be of the correct length to uniformly maintain the luminaire heights shown on the Drawings. Variation in mounting individual luminaires shall not exceed 1/4 inch. Height shall not vary more than 1/2 inch from the floor mounting height shown on the Drawings. Luminaires hung in continuous runs shall be installed absolutely level and in line with each other. Hanging devices shall comply with NEC requirements. Unless otherwise noted, use single stem hangers. Chains or threaded rods will only be permitted to support luminaires in those mechanical spaces where no other means of support is attainable, and only if fixtures are installed absolutely level with no looseness for movement the installation is approved by the NEC.

2.4 BRACKET MOUNTED LUMINAIRES

- A. For each bracket mounted luminaire, provide flanged metal stem attached to outlet box, with threaded end suitable for supporting the luminaire rigidly in specified position. Flanged part of the luminaire shall be of broad base type, secured to the outlet box at not less than three points.

2.5 FINISHES

- A. Unless otherwise noted, all finishes shall be as selected by the Architect.
- B. Luminaire finishes shall be applied in a manner that will assure a durable, wear resistant surface.
- C. Unless otherwise noted, fluorescent lamp luminaires with baked-on white synthetic enamel finishes shall have a minimum reflectance of 85%.
- D. All Alzak parabolic reflectors shall be guaranteed against discoloration for a minimum of ten years, and, in the event of premature discoloration, shall be replaced by the manufacturer at no cost to the Owner.
- E. Aluminum reflectors shall be finished specular, semi-specular, or diffuse as specified and shall meet or exceed Alzak specifications.
- F. Reflector finish color shall be as selected by the Architect.
- G. Unless otherwise specified, all painted surfaces on exterior luminaires shall use fluoropolymer paint with an outdoor life expectancy of not less than 20 years. Surfaces shall be prepared, primed, and material applied in accordance with the manufacturer's requirements.

2.6 LENSES

- A. Plastic used for lenses and diffusers shall be formed of colorless 100% virgin acrylic as manufactured by Rohm & Haas, Dupont, or acceptable equal. Troffer lenses shall be minimum 0.125" thick.

- B. Glass used for lenses, reflectors, diffusers, and luminaires shall be tempered for high impact and heat resistance. The glass shall have a transmittance of not less than 88%, unless otherwise indicated. For exterior luminaire use tempered borosilicate glass Corning #7740 or acceptable equal.
- C. All lenses, louvers, and other light diffusing elements shall be removable and positively held so that hinging or other normal motion will not cause them to drop out.
- D. All lenses shall be turned over to the Owner clean and free of dust or finger prints.
- E. Spread lenses shall be provided with notches or locking devices to insure that lens orientation is not disturbed during luminaire lamp replacement or cleaning.
- F. Unless otherwise noted, metal halide luminaires shall be provided with heat and shock tempered glass enclosures capable of containment of hot quartz arc tube particles as recommended by luminaire and lamp manufacturers.

2.7 LAMPS

- A. Lamps shall be manufactured by General Electric, Philips, or Osram/Sylvania unless otherwise noted.
- B. Provide all lamps as indicated on the Luminaire Schedule and the applicable Contract Documents.
- C. Lamps of a given type shall be produced by one manufacturer.
- D. All incandescent lamps shall be inside frosted and rated for 130 volt operation, unless otherwise specified.
- E. Provide ten percent spare lamps for all lamps specified in the lighting fixture schedule.
- F. Fluorescent or incandescent lamps not protected by suitable lens diffusers and used in dining areas, kitchens, food server areas, food display areas, bars, food counters or other applicable eating or drinking areas shall be fully protected with Teflon coating, tube guards, or other means as required by the NEC. Teflon coating shall be as provided by Shatter-Shield or equal.

2.8 LAMP HOLDERS

- A. Lamp sockets shall be rigidly and securely screwed to luminaire housing.
- B. All lamp sockets shall be suitable for the specified lamps and shall be set so as to allow for specified performance of the luminaire by positioning lamps in optically correct relation to lenses, reflectors, baffles and light diffusers.
- C. Where adjustable socket positions are provided, socket shall be preset in the factory for the lamp specified. Where different socket positions are specified for the same luminaire, sockets shall be preset as required, and cartons marked accordingly.
- D. Incandescent lampholders shall have a UL listed, heavy duty porcelain body and a nickel-plated brass screw shell prelubricated with silicone compound.
- E. Unless otherwise noted, provide medium base sockets for incandescent lamps up to and including 250 watts, and mogul based sockets from 300 watts up to 1500 watts (rated for 1500 watts, 600 volt service).
- F. Fluorescent lampholders shall be made of heavy white thermoset urea plastic with definite lock-in feature and silver plated contacts. Outdoor lampholders shall be compression type with neoprene

gasketing. Sockets with open circuit voltage over 300 volts shall be of the safety type and designed to open supply circuit on lamp removal.

- G. High intensity discharge lampholder shall have a porcelain body and a nickel-plated brass screw shell, prelubricated with silicone compound. Unless otherwise noted, contacts shall be made of spring-loaded silver-plated phosphor bronze.
- H. Fluorescent lampholders shall be designed to locate lamps at the optimum distance away from the grounding element for proper lamp start as required for the specified lamp and ballast combination.

2.9 WIRING

- A. Wiring between fluorescent lampholders and associated operating and starting equipment shall be of similar or heavier gauge than the leads furnished with the approved types of ballasts, with equal or better insulating and heat resisting characteristics.
- B. Wiring shall be protected with tape or tubing at all points where abrasion may occur.
- C. Wiring shall be concealed within luminaire construction except where the luminaire design or mounting dictates otherwise.
- D. Connections of wires to terminals of lampholders and other accessories shall be made in a neat and workmanlike manner and be electrically and mechanically secure with no protruding loose strands. The number of wires extending to or from the terminals of a lampholder or other accessory shall not exceed the number which the accessory is designed to accommodate.
- E. Wiring channels and wireways shall be free from projections, screw points, and rough or sharp edges throughout; and all points or edges over which conductors may pass and be subject to damage or wear shall be rounded or bushed.
- F. Insulated bushings shall be installed at points of entrance and exit wiring.
- G. Splices in internal wiring shall be made with approved insulated "Wire Nut" type mechanical connectors, suitable for the temperature and voltage conditions to which they will be subjected.
- H. For 120 volt luminaire wiring, use 300 volt, 150°C non-asbestos wire beginning at separately mounted outlet box unless higher temperature is required by luminaire design.
- I. For luminaire wiring of units connected to voltages higher than 120 volts use 600 volt, 105°C appliance type (AWM) wire approved for luminaire wiring, beginning at separately mounted outlet box.
- J. All luminaires shall be completely wired at the factory.
- K. All luminaires shall be properly grounded as required by applicable codes.

2.10 FLUORESCENT BALLASTS AND HIGH INTENSITY DISCHARGE BALLASTS

- A. All fluorescent and high intensity discharge lamp ballasts shall conform to the following:
 - 1. UL and ANSI specifications with labels and/or symbols of approval by the UL and certification by CBM as tested by ETL.
 - 2. The component parts shall be designed, fabricated, and assembled in accordance with the NEC and other applicable codes.

3. Ballasts shall provide safe and reliable operation of the specified lamps.
 4. Ballasts installed within the same luminaire type shall be identical in all respects.
 5. Fluorescent lamp ballasts shall be rigidly mounted to the inside of the top of the luminaire housings, with ballast surfaces and housing in complete contact for efficient conduction of ballast heat to prevent overheating or cycling. Ballasts shall be readily removable for replacement.
 6. Ballasts shall be designed for operation at 60 Hz. nominal, and shall operate at the nominal voltages indicated on label.
 7. Secure ballasts firmly in luminaires to prevent vibrations.
 8. Contractor shall provide ballast with operating voltage compatible with branch circuit voltage as shown on Contract Drawings.
 9. Unless otherwise noted, all ballasts shall be factory installed and wired.
- B. All electromagnetic fluorescent ballasts shall conform to the following:
1. Ballasts shall be manufactured by the following manufacturers: Osram/Sylvania, Advance, General Electric, or Universal Lighting Technologies.
 2. Ballasts shall be Class P and meet ANSI C62.41 standards for transient protection.
 3. Provide the best sound-rating available for the lamps and ballast combination. Ballasts found by the Architect to be unduly noisy shall be replaced, without charge, prior to acceptance of the job.
 4. Fluorescent luminaires with two lamps or a multiple of two lamps shall have two-lamp ballasts.
- C. All electronic fluorescent ballasts shall conform to the following:
1. Ballasts shall be manufactured by Osram/Sylvania, GE, Advance or Universal Lighting Technologies.
 2. Ballasts shall be Instant Start except as follows:
 - a. In locations where occupancy sensors are to be used to control the lighting and areas that are expected to be switched frequently (more than 6 times per day), Programmed Rapid Start ballasts shall be utilized.
 - b. T5 and T5HO ballasts shall be Programmed Rapid Start.
 3. Instant Start ballasts shall operate as a parallel circuit, allowing remaining lamp(s) to maintain full light output if one or more lamps fail.
 4. Ballasts shall be high frequency electronic type and operate at a frequency above 20 kHz with no visible flicker. Programmed rapid start ballasts shall operate at a frequency above 42 kHz.
 5. Ballasts shall be CSA certified.

6. Ballasts shall have a power factor of 97% or above.
 7. Ballasts shall have a Ballast Factors greater than the following per ANSI C82.11:
 - a. Instant Start: 85%
 - b. Programmed Rapid Start: 85%
 - c. T5 and T5HO Programmed Rapid Start: 95%
 8. Ballasts shall have a total harmonic distortion rating of 20% or less.
 9. Ballasts shall be sound rated "A".
 10. Ballasts shall be Class P and meet ANSI C62.41 standards for transient protection.
 11. Ballasts shall have an average lamp current crest factor below 1.7.
 12. Ballasts shall maintain constant light output over operating ranges of 108V to 132V (120V ballasts) and 249V to 305V (277V ballasts), 50/60 Hz.
 13. Ballasts shall withstand line transients as defined in ANSI/IEEE C62.41, Category A.
 14. Ballasts shall meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18, for non-consumer equipment.
 15. Where applicable, ballasts shall meet minimum efficacy standards of Public Law No. 100-357, National Appliance Energy Conservation Amendments of 1988, and Canadian Efficiency Standards.
 16. Ballasts shall have a minimum manufacturer=s warranty of 3 years including allowance for labor costs to replace defective ballasts.
 17. Ballasts for T5 lamps and smaller shall have end-of-life shutdown circuitry to prevent the overheating or damage of lamp bases and sockets.
- D. All fluorescent dimming ballasts shall conform to the following:
1. Ballasts shall be of the Hi-Lume series by Lutron or engineer-approved equal.
 2. Electronic dimming ballasts and controls shall be made by the same manufacturer.
 3. Dimming shall be smooth and continuous without flicker down to 1% light output (5% light output for T-5 lamps).
 4. Ballasts shall be capable of striking lamps at any light level without first flashing at full light.
 5. Different lamp lengths of the same lamp type shall dim evenly when controlled by the same dimmer.
 6. Ballasts shall be inaudible in a room with 27 decibel ambient noise level, throughout the full dimming range.
 7. Ballasts shall comply with FCC Part 18 regulations and shall not interfere with other properly installed electrical equipment.

8. Ballasts shall be Class P and meet ANSI C62.41 standards for transient protection.
 9. Ballasts shall be sound rated "A".
 10. Ballasts shall have a power factor greater than 90%.
- E. All exterior pole mounted luminaires shall conform to the following:
1. Provide reinforced concrete bases for all exterior pole mounted luminaires in accordance with the manufacturer's recommendations. The bases shall be designed to prevent overturning or permanent deflection in sustained winds up to 100 miles per hour with gusts to 130 miles per hour. Take into account the existing soil conditions in sizing the bases and submit shop drawings of base design for approval by electrical and structural engineers.
 2. Each pole over 8 feet in height shall be manufactured with an accessible grounding lug. If access is provided via handhole, handhole must be a minimum of 2" x 4" and have raintight cover.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Provide luminaires at locations, and of types, as indicated on the Contract Drawings.
- B. Do not scale electrical drawings for exact location of the luminaires. Consult the Architectural Reflected Ceiling Plans for the proper locations of luminaires. Report immediately to the Architect any discrepancy between the Architectural Reflected Ceiling Plans and the electrical documents.
- C. Prior to submittal of shop drawings and fabrication, check for adequate headroom and non-interference with other equipment, such as ducts, pipes, and openings.
- D. Install each luminaire properly and safely. Provide hangers, rods, mounting brackets, supports, frames, yokes, support bars and any other equipment required for a complete installation.
- E. Each luminaire shall be packaged with complete instructions and illustrations showing proper installation procedures. Install luminaire in strict conformance with manufacturer's recommendation and instructions.
- F. Rigidly align continuous rows of luminaires for true in-line appearance, subject to Architect's approval.
- G. Install pendant luminaires plumb, and at the height from the floor specified or indicated on the Drawings. In cases where conditions make this impractical, refer to the Architect and install as directed. Use ball aligners and canopies on pendant luminaires unless otherwise noted.
- H. Do not install luminaire parts such as finishing plates and trims for recessed luminaires until all plastering, painting or other activities that may mar fittings' finishes have been completed.
- I. Install reflector cones, baffles, aperture plates, air controlling elements for air handling luminaires, and decorative elements after completion of ceiling tile installation, painting, and general cleanup.
- J. Exterior poles, bollards, bases, and any other luminaire or luminaire components with scratched or damaged finishes shall be repainted to match specified color or replaced if deemed necessary by the Architect.

- K. The Contractor shall be required to protect luminaires from damage during installation. The Contractor shall replace, at no extra cost, any broken luminaires, glassware, plastics, lamps, etc. up to the time of final acceptance by the Architect.
- L. Upon completion of the installation, all lighting equipment must be in perfect operating order and free from defects in condition, operation, and finish.
- M. Luminaires, lamps, and all other pertinent equipment shall be clean and free from dust, plaster, paint spots, or finger prints.
- N. Housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum. Where cast aluminum housings are used, they shall be given two coats of asphaltum paint prior to installation.
- O. Provide 1/8" thick x 2" diameter solid neoprene grommets at every mounting point for all luminaire surfaces mounted to concrete structure to prevent direct contact between housing and concrete.
- P. All mounted wall box dimmers shall be under a separate cover plate. Do not gang with other devices.

3.2 FRAMES AND SUPPORTS

- A. When necessary to meet Code requirements, an enclosure shall be constructed to provide a 1-hour fire rating.
- B. Attachment devices shall be made of formed, rolled, or cast metal shapes with the required rigidity and strength to maintain continuous alignment of the installed luminaires.
- C. When necessary to meet Code or specific project requirements, provide special supports for recessed luminaires as follows:
 - 1. Provide earthquake clips.
 - 2. Secure luminaires to building structures with safety chains.
- D. Provide support as follows:
 - 1. Except as otherwise noted, as a minimum procedure, support luminaires as follows:
 - a. Where weight is less than five pounds, support luminaire from its outlet box by means of an interposed metal strap.
 - b. Where weight is from five to fifty pounds, support luminaire from its outlet box by means of hickey or other direct threaded connected.
 - c. Where weight exceeds fifty pounds, support luminaire directly from structural slab, deck, or framing.
 - d. Where luminaires and ceiling are such as to require luminaire support from ceiling opening frames, include in the electric work the members necessary to tie back the ceiling opening frames to ceiling suspension members or slabs so as to provide independent support for the luminaires as noted above. The weight of the luminaire shall not cause any bending in the ceiling system.
 - 2. In conjunction with luminaires weighing less than fifty pounds, the above restriction against

supporting from suspended ceiling splines, runners or bars in the plane of the ceiling will be waived for ceilings which have been specifically approved for the weight and arrangement of luminaires being installed. Any support members or other appurtenances however, required to tie in/or adapt the luminaires and their ceiling opening frames (if any) to ceiling in an approved manner shall be included as part of the electric work.

3.3 AIMING AND ADJUSTMENTS

- A. All adjustable lighting units shall be aimed, focused, and locked, etc., by the Contractor under the supervision of the Architect. All aiming and adjusting shall be carried out after the entire installation is complete. All ladders and scaffolding, etc., required shall be furnished by the Contractor at the direction of the Architect. As aiming and adjusting is completed, locking setscrews, bolts, and nuts shall be tightened securely.
- B. Where possible, units shall be focused during normal working daytime hours. However, where daylighting interferes with aiming and focusing, the aiming shall be performed at night.

3.4 COORDINATION WITH AMBIENT CONDITIONS

- A. This Contractor is responsible for coordinating the characteristics and the UL labeling of the luminaires and their components with the ambient conditions which will exist when the luminaires are installed. These areas of coordination include, but are not limited to, the following:
 - 1. Wet location labels.
 - 2. Damp location labels.
 - 3. Dimming ballasts.
 - 4. Very low heat rise ballasts.
 - 5. Explosion-proof construction.
 - 6. Plenums and air handling spaces.
 - 7. Fire rated ceilings.
 - 8. Low density ceiling.
 - 9. Insulated ceilings.

END OF SECTION 16500

SECTION 16770 - PUBLIC ADDRESS SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

- 1.2 Provide all equipment, accessories, and material, complete, and in strict accordance with Specifications and Drawings, as required for necessary and proper operation of these systems not specified or described herein or shown on the drawings shall be deemed part of the Specifications.

- 1.3 **SHOP DRAWINGS:** All submittals for prior approval and the submittal of the successful bidding Contractor shall contain the following:

1. Provide complete one-line wiring schematic showing all elements of the sound reinforcement system.
2. Provide complete "catalog cuts" of each separate item of equipment. Specific schematics and modifications to the submitted equipment (if other than that specified) shall be supplied. Specific, written statements from the proposed Manufacturer (if other than that specified) detailing the methods of testing and certifying the catalog performance specifications and the Manufacturer's conformance to RS-490 and other current EIA standards.
3. Speaker mounting details.

1.4 OPERATION AND MAINTENANCE MANUALS:

1. Provide three (3) bound sets of operation instructions, maintenance recommendations and parts lists for systems supplied. Including wiring and connection diagrams modified to reflect as-built conditions.

- 1.5 In all cases the work is to be complete and operational to the extent delineated by this outline. Any material and/or equipment necessary for the proper operation of the outlined system which is not specified or described herein shall be deemed part of this Specification.

PART 2 - PRODUCTS

2.1 MANUFACTURER AND SUBCONTRACTOR

1. Approved Manufacturer: SoundTube, Atlas Sound, Denon, Bose or equal, components may be from single manufacturer or multiple.

2.2 ACCEPTANCE OF SUBCONTRACTORS

- A. Subcontractors desiring acceptable subcontractor status shall submit documentation conforming to Part 1 and the following requirements for prior consideration by the owner.
- B. The Subcontractor shall show satisfactory evidence that he is an experienced sound installer who is the factory authorized distributor of the equipment manufacturers he proposed to use and shall have

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installed and maintained similar apparatus as the same company for a period of seven (7) years or more.

- C. The Subcontractor shall present a list of at least (5) similar jobs satisfactorily installed and maintained by this same company and management during the past four (4) years of a similar or greater size and scope.
- D. The Subcontractor shall, upon request, present documentation attesting to his financial strength, credit rating, ability to meet past production schedules, quality of workmanship and service response and performance.
- E. The Subcontractor shall present the name and resumes of the individuals to be responsible for the design and integration of their proposed system the same individuals will be responsible for carrying out the design and integration.
- F. The Subcontractor shall maintain in this same company a fully equipped service organization, capable of furnishing adequate inspection and service to the equipment, including standard replacement parts. The Subcontractor shall be able to produce proof of current factory authorized service status and satisfactory, prompt service response and performance.

2.3 SOUND REINFORCEMENT SYSTEM

A. Public Address/Paging

- 1. The Public Address/Paging system design is based on a multiple zone configuration with capabilities to provide program source and/or voice paging to each zone separately, all call or emergency override. Each zone shall be controlled via local switching and/or telephone access. The following zones shall be configured for voice paging and/or background music.

Lower Level Zones

- Common Areas and Locker Rooms
- Pool
- Party Room
- Office Areas

The Main system shall consist of ceiling and wall mounted speakers as indicated. Main equipment rack shall house all necessary amplifiers, mixers, special interfaces, zone control electronics and music source equipment. Contractor shall be responsible for all switching and control equipment weather indicated or not.

Provide separate all-call input at main sound system to accept voice evacuation signal from the fire alarm system. Coordinate exact interface requirements with the fire alarm system supplier. This input will provide ancillary back-up support only to the U.L. listed voice evacuation system specified else ware.

2.4 EQUIPMENT

A. CONTROL ELECTRONICS AND SIGNAL PROCESSING

Main System

- 1. Bose Freespace E-4-II (provide quantity as necessary with all necessary software and rack

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- mounting hardware)
- 2. Bose 29856 standard volume control interface

B. SOURCE COMPONENTS

- 1. Cassette/CD combination Player
Denon DN-T645

C. AMPLIFIERS

Main System

- 1. Bose Freespace E-4-II or Bose M-2150 shall be acceptable.

D. LOUDSPEAKERS/VOLUME ATTENUATORS

Type 1 Large format pendant mount, SoundTube HP890i with mounting hardware.

Type 2 Ceiling mount Atlas Sound FAP42T with appropriate tile bridge in drop ceiling areas, Bose Model 16 with appropriate tile bridge and plenum rated enclosure shall also be acceptable.

Type 3 Wall or surface mount Atlas Sound W115AT-WH with mounting hardware, Bose Model 32SE with appropriate equalization shall also be acceptable.

Volume Ctl. Wall mount volume controls shall be Atlas Sound AT-10.

E. MICROPHONES / TELEPHONE INTERFACE

Main System

- 1. Valcom V2924A zone page control.
- 2. Shure 450 series desk top microphone. One required.

F. CABLES & WIRING

- 1. Acceptable Product: BELDEN, PAIGE, WESTPENN

G. RACKWARE AND MISCELLANEOUS EQUIPMENT

- 1. Main Equipment
 - a. Rack (quantity: 1)
 - Acceptable Product: MIDDLE ATLANTIC rack sized to accommodate audio head end equipment.

H. SPEAKER MOUNTING AND RIGGING

- 1. All rigging and mounting to be per manufacturers design and recommendations. All mounting applications to be pre-approved in writing by speaker manufacturer.
- 2. Rigging requirements: Safety factor employed in design to be not less than 5:1

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- a. Equipment shall be manufactured, installed, operated and maintained in such a way that its safety and function is assured.
- b. Equipment shall be inspected before the initial use, after any alterations to the operation or design of the system, and at regular intervals. These inspections shall be conducted by specialists in rigging equipment and installation
- c. Operation, maintenance and repair work on rigging equipment shall be done by those persons having proper training and qualifications.
- d. Persons charged with operation of the rigging system shall be thoroughly instructed in the following and sign a statement indicating they have received instruction in the safe operation of the system:
 - 1) Operation and function of the equipment
 - 2) Safe recommended use of the equipment
 - 3) Necessary routine maintenance work for safe operation
- e. A manufacturer's label or name shall be conspicuously and permanently attached to each piece of rigging equipment and hardware.
- f. Wire rope shall be attached safely and durably. Wire rope shall have a safety factor of at least eight (8). Wire rope to be a minimum of 0.125 inches in diameter with thimbles at each end.

2.5 INSTALLATION AND TESTING

- A. All installation shall be done in a neat professional manner. All raceways shall be tagged as to destination. All wiring and connections and the installation of all equipment shall be accomplished under the direct supervision of the manufacturer's authorized agent. The manufacturer's representative shall check out the complete system, including all components and wiring, and shall certify all systems and sub-systems to be in proper operational condition.
- B. Transformers, distribution amplifiers, etc., shall be used throughout all systems to ensure voltage and impedance match between all equipment.
- C. All equipment and controls shall be clearly labeled to purpose and function.
- D. The approved local service organization shall maintain a one year warranty on the entire system.
- E. Provide all required testing apparatus to successfully complete the equalization and test. This adjustment is made to realize maximum acoustic gain and optimum tonal balance from the sound system throughout each area.
- F. All cable shall be installed in EMT or cable management system.
- G. General
 - 1. Install rack-mounted equipment with black 10-32 button head machine screws with Allen drive and protective nylon washer.
 - 2. Provide shaft locks or security covers on non-user operated equipment having front panel controls. Install covers at conclusion of Acceptance Testing.

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3. Fabricate custom rack panels using 0.125 inch thick aluminum, standard EIA sizes, brushed black anodized finish unless otherwise noted. Racks shall be completely enclosed with perforated front and vented rear doors having hinges, locks, blank panels, vent panels, blower fans as required and keys. Rack color shall be black.
4. Custom receptacle plates (if required) shall be 3/16-inch thick aluminum, brushed anodized or stainless steel as shown on drawings. Sound Contractor is responsible to verify plate finish with the Architect. Plastic plates are not acceptable.
5. Engrave panels and plates with 0.125 inch block sans serif character unless noted. On dark panels or push buttons, use white letters; use black letters on stainless steel or brushed natural aluminum.
6. Custom plates and panels or cable terminations, use audio XLR-type connectors with gold-plated contacts.

H. System Wiring

1. Take precautions to prevent and guard against electromagnetic and electrostatic hum. For line-level audio signals, float cable shields at the output of source device. Shields not connected to folded back over cable jacket and covered with heat-shrink tubing. Do not cut off unused shields.
2. Exercise care in wiring; damaged cables or equipment will not be accepted. Isolate cables of different signals or different levels; and separate, organize and route to restrict channel crosstalk or feedback oscillation in any amplifier section. Keep wiring separated into groups for microphone and line-level circuits, loudspeaker circuits and power circuits.
3. Make joints and connections with rosin-core solder or with mechanical connectors approved by the Engineer; where spade lugs are used, crimp properly with ratchet type tool. Spade lugs mounted on 22 gauge or smaller cable to be soldered after crimping.
4. Wiring entering equipment racks should connect via terminal blocks (Cinch 140-142 Series); terminal blocks shall be fully exposed, leveled and mounted on 3/4-inch plywood board painted black. If quantity of terminals is too numerous to fit in rack, terminal blocks may be located on wall mounted plywood terminal board adjacent to rack. Mounting boards to be 3/4-inch A/C grade or hardwood plywood painted flat black. Terminal board wiring to meet the same requirements as internal rack wiring described below.
5. Route microphone, audio line and control wiring from receptacle plate/chassis to patch panel/rack. Spliced cables are not permitted.
6. Connect cable to active components through screw terminal connections and spade lugs whenever available. Make connections to speaker transformers with properly sized closed end connectors crimped with factory approved ratchet type tool. Wire nut or Scotchlock connectors are not acceptable. Do not wrap audio cable splices or connections with adhesive backed tape.
7. Run vertical wiring inside rack in properly sized plastic raceway with Snap-On covers (Panduit Type E series). Mount raceways on full-length 3/4-inch plywood backboards

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attached to rack slides. Horizontal wiring in rack to be neatly tied in manageable bundles with cable lengths cut to minimize excess cable slack but still allow for service and testing. Provide horizontal support bars if cable bundles sag. Neatly bundle excess AC power cable from rack mounted equipment with plastic cable ties. Rack wiring to be bundled with plastic cable ties or lacing twine. Electrical tape and adhesive backed cable tie anchors are not acceptable.

8. Connect loudspeakers electrically in phase, using the same wire color code for speaker wiring throughout the project.
9. Wiring and connections shall be completely visible and labeled in rack. Termination resistors shall be 2 watt 5 percent tolerance; fully visible and not concealed within equipment or connectors.

I. Equipment and Cable Labeling

1. Provide labels on the front and rear of active equipment mounted in racks. Mount labels in a neat, plumb and permanent manner.
2. Labels to have 1/8-inch high characters typical. Labels to be black with white characters except where indicated.
3. Cables and wiring to logically, legible and permanently labeled for easy identification. Labels on cables to be adhesive strip type covered with clear heat-shrink tubing. Factory-stamped heat-shrink tubing may be used in lieu of the adhesive strip style label. Hand-written or self-laminating labels not acceptable.
4. Wiring designations to be an alphanumeric code that is unique for each cable. Locate the cable designation at the start and end of each cable run and within 3 inches of the point of termination or connection. For cable runs that have 3 intermediate splice points at riser junction boxes, the cable shall have the same designation throughout with an additional suffix to indicate each segment of the run. Actual cable designation codes to system schematic drawings included with Operation and Maintenance Manuals.
5. Label each terminal strip with a unique identification code in addition to a numerical label for each terminal. Show terminal strip codes on system schematic drawings included with Operation and Maintenance Manuals.
6. Provide adhesive labels on the rear of equipment where cables attach to indicate the designation of the cable connected at that point.

J. Inspection of Sound System

1. Perform the following inspections of the sound system and submit to the Engineer the written results of each inspection for inclusion in the permanent records of the sound system.
2. Measure and record the impedance of each loudspeaker line before connecting it to the output of its respective amplifier. The load impedance shall be equal to or greater than the rated impedance. Record the total impedance.

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3. Measure and record the input impedance of any active device used to terminate passive devices and record the total impedance of all such devices. Record the dc resistance of any terminating resistor used.

K. Instruction

1. Sound Contractor shall furnish a minimum of four (4) hours of in-service training to facility and maintenance personnel. Sessions shall be scheduled with the client through the Architect with at least seven (7) days advance notice. These sessions shall be conducted by professional Training staff employed by the Sound Contractor for the sole purpose of customer training and support. Training program shall include system orientation, system operation procedures, adjusting, troubleshooting, preventative maintenance and servicing.

END OF SECTION 16770

SECTION 16780 - LOW VOLTAGE SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:

1. This document describes the products and execution requirements relating to furnishing and installing a complete and totally cabled low voltage system also referred to as a structured cabling system (including data, voice and broadband). Horizontal cabling comprised of copper cabling, and support systems are covered under this document.
2. All cables and related terminations, support and grounding hardware shall be furnished, installed, wired, tested, labeled, and documented by the Telecommunications contractor as detailed in this document.
3. Product specifications, general design considerations, and installation guidelines are provided in this document. Telecommunications outlets, typical installation details, cable routing and outlet types per low-voltage systems drawings. If the bid documents are in conflict, this specification shall take precedence. The successful vendor shall meet or exceed all requirements for the cable system described in this document.

B. Related Work Specified in Division 16000

1. Electrical General Provisions – 16010
2. Raceways and Boxes – 16110
3. Grounding Systems - 16450

C. Related Work Specified in Other Divisions of these Specifications

1. Finish Painting
2. Concrete

1.2 SECTION INCLUDES

- A. Copper based horizontal cable distribution.
- B. Cabinet system.
- C. Cable runway/raceway.

1.3 REGULATORY REQUIREMENTS AND STANDARDS

- A. Except as modified by governing codes, local authority having jurisdiction and by Contract Documents, comply with the latest applicable provisions and recommendations of the following:
 1. NFPA 70 - National Electrical Code (NEC).

- a. Comply with articles 250, 725, 770 and 800-series articles applicable to construction and installation of communications systems.
2. IEEE - Recommended Practice for Electrical Power Systems in Commercial Buildings.
3. NEMA - Enclosures for Electrical Equipment.
4. EIA - Electronic Industries Association and TIA - Telecommunications Industry Association.
 - a. Comply with EIA/TIA 568 – Commercial Building Wiring Standards
 - b. Comply with EIA/TIA 569 – Commercial Building Standard for Telecommunications Pathways and Spaces
 - c. Comply with EIA/TIA 606 – Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
 - d. Comply with EIA/TIA 607 – Commercial Building Grounding and Bonding Requirements for Telecommunicaitons
5. UL - Underwriters Laboratories.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's data on all components listed in Part 2 – Products of this specification and as specified on the systems plans.
- B. Shop Drawings: Submit layout drawings of the low voltage system as detailed in this specification and on the systems plans.
- C. Wiring Diagrams: Submit wiring diagrams for all telecommunications systems including rack and terminal connections.
- D. The telecommunications contractor shall receive approval from the Owners on all substitutions of material. No substituted materials shall be installed except by written approval from the Owner.

1.5 WORK INCLUDED

- A. The work included under this specification consists of furnishing all labor, equipment, materials, and supplies and performing all operations necessary to complete the installation of this structured cabling system in compliance with the specifications and drawings. The Telecommunications contractor will provide and install all of the required material to form a complete system whether specifically addressed in the technical specifications or not.
- B. The work shall include, but not be limited to the following:
 1. Furnish and install a complete data, voice and broadband system wiring infrastructure.
 2. Furnish, install, and terminate all UTP, and RG6 cable.
 3. Furnish and install all conduit, backboxes, wall plates, jacks, patch panels, and patch cords.
 4. Furnish and install all required cabinets and/or racks as required and as indicated.
 5. Furnish any other material required to form a complete system.

6. Perform link or channel testing (100% of horizontal and/or backbone links/channels) and certification of all components.
7. Furnish test results of all cabling to the owner on disk and paper format, listed by each closet, then by workstation ID.
8. Provide owner training and documentation. (Testing documentation and As-built drawings)

1.6 PROJECT RECORD DOCUMENTS

- A. General: Provide Project Record Documents of Low Voltage Systems Work in accordance with the Contract Documents.
- B. During construction keep an accurate record of all deviations between the work as shown on Drawings and that which is actually installed. Keep this record set of prints at job site for review by the Architect/Engineer.
- C. Upon completion of the installation, obtain from the Architect a complete set of drawings or electronic drawing files. Enter therein, in a neat and accurate manner, a complete record of all revisions to the original Drawings as actually installed. The cost for drawings and for making required changes shall be borne by this Contractor. Submit one (1) set of revised drawings to the Architect/Engineer for review. After review by the Architect/Engineer for transmittal to the Owner.

1.7 QUALITY ASSURANCE

- A. Provide structured cabling systems that are of one manufacturer, unless noted otherwise, so as to maintain manufacturer's performance guarantees.

1.8 QUALIFICATIONS

- A. Installer: Company specializing in installing tele-data and broadband systems, with a minimum of 5 years successful experience in installing similar systems.
- B. Contractor shall be an authorized and certified cabling system installer for the particular system.

PART 2 - PRODUCTS

2.1 STANDARDS

- A. Except as modified by governing codes and the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 1. Local telephone company regulations.
- B. Any deviations from the Contract Documents shall immediately be brought to the attention of the Architect/Engineer.

2.2 DELIVERY, STORAGE AND HANDLING

- A. Deliver components and equipment in factory-fabricated containers or wrappings which properly protect equipment from damage.

- B. Store equipment and components in original packaging. Store inside a well ventilated space protected from weather, moisture, soiling, humidity and extreme temperatures.
- C. Handling equipment and components carefully to prevent damage. Do not install damaged units or components; replace with new.

2.3 RACEWAYS

- A. Minimum size conduit shall be 1" with no "looping" between outlets.
- B. EMT shall be utilized for all raceways within the building unless noted otherwise on the plans.
- C. Arrange raceway runs less than 100 feet from point to point so that they contain no more than 2-90 degree standard factory bends or 3-90 degree 24 inch radius bends. Provide pull boxes in raceway runs exceeding 100 feet from point to point with more than 1-90 degree bend. Raceway runs shall not contain square or oval conduit fittings ("Condulets"). Enter feeder raceways to telephone terminal boards top or bottom on the extreme right or left side.
- D. Refer to 16110 for acceptable underground raceways.

2.4 COPPER BASED HORIZONTAL CABLE DISTRIBUTION

- A. Manufacturers:
 - 1. Siemon
 - 2. CommScope
 - 3. Belden
- B. Cable:
 - 1. Telecommunication (Data/Voice):
 - a. Category 6, 4 pair, 100 ohm, unshielded twisted pair (UTP), plenum rated.
 - b. Siemon System 6 UTP - US.
 - c. Jacket color to be blue for Data and white for Voice.
 - 2. Broadband:
 - a. RG-6, quad shield, 75 ohm, 3 Ghz, plenum rated.
 - b. CommScope or Belden
 - c. Jacket color to be chosen by The City of Raton.
- C. Jacks:
 - 1. Telecommunication (Data/Voice):
 - a. Siemon Max6 Flat Jacks, T568A/B, pinned out to T568B.
 - b. Voice jacks to be verified with the City of Raton.
 - c. Color to be blue for Data and white for Voice.

2. Broadband:
 - a. Siemon Coax CT Couplers with PPC EX Series F-type adapters
 - b. F-type adapters shall be rated for 3 Ghz
 - c. Color to be red.
- D. Faceplates:
 1. Telecommunication (Data/Voice)
 - a. Siemon Max Modular Faceplates, single gang.
 - b. Refer to Sheets E1.21 and E3.10 for number of outlets per faceplate.
 - c. Wall mounted phones designated with "W" shall have faceplates with wall phone mounting hardware.
 - d. Provide blank inserts for any unused holes.
 - e. Color by architect.
- E. Telecommunications Cabinet and Patch Panel (Data)
 1. Enclosure
 - a. Wall mounted, lockable Cabinet with exhaust fan.
 - b. Hoffman # DBS242412G.
 - c. Provide grounding and bonding.
 - d. Provide fan, fan filter and finger guard.
 - e. Provide patch panel rack angles.
 - f. Provide all required accessories for mounting of cabinet.
 2. Data Patch Panel
 - a. Siemon Max 48-port patch panel.
 - b. Provide Siemon Max6 Flat Jacks, T568A/B, pinned out to T568B.
 - c. Provide Siemon WM Series Horizontal Cable Manager # WM-144-5.
- F. Wall Mounted Voice Patch Panel:
 1. Siemon Max 48-port patch panel.
 2. Provide Siemon Max6 Flat Jacks, T568A/B, pinned out to T568B.
 - a. Voice jacks to be verified with the City of Raton.
 3. Provide Siemon Hinged Stand-Off Bracket # SBH-4.
 4. Provide Siemon WM Series Horizontal Cable Manager # WM-144-5.
- G. Patch Cable:
 1. Data/Voice:
 - a. Outlet (Workstation):
 - i. Category 6, 4 pair, 100 ohm, unshielded twisted pair (UTP).
 - ii. Siemon System 6 UTP MC Modular Patch Cords.
 - iii. Provide (2) blue for data and (1) white for voice per outlet in 10' lengths.

- b. Data Patch Panel:
 - i. Category 6, 4 pair, 100 ohm, unshielded twisted pair (UTP).
 - ii. Siemon System 6 UTP MC Modular Patch Cords.
 - iii. Provide (1) per port at each patch panel and 10% spare
 - iv. Provide blue for data per outlet in 4' lengths.

- c. Voice Patch Panel:
 - i. Category 6, 4 pair, 100 ohm, unshielded twisted pair (UTP).
 - ii. Siemon System 6 UTP MC Modular Patch Cords.
 - iii. Provide (1) per port at each patch panel and 10% spare
 - iv. Provide (2) white for voice per outlet in 4' lengths.
 - v. Provide (6) patch cords for the local telephone company.

2. Broadband

- a. Outlet (Workstation):
 - i. RG-6, quad shield, 75 ohm, 3Ghz, F-connectors.
 - ii. Provide (1) per jack at each outlet and 10% spare
 - iii. Provide half in a 6' length and half in a 12' length.
 - iv. Jacket Colors shall be per the City of Raton.

2.5 TELECOMMUNICATIONS CLOSET BACKBOARDS

- A. Provide 3/4" fire rated plywood backboard.
- B. Install with fire brand showing.
- C. Refer to plans for quantities.

2.6 PUNCH DOWN BLOCKS AND BACKBOARDS

- A. Provide quantity of 66M150 Blocks as required (minimum of two).
- B. Provide (1) AllenTel Half Module, Blue, Metal Backboard #GB183AIM.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Install wire and cable in accordance with drawings, manufacturer's instructions and EIA/TIA 568 and 569.
- B. Coordinate installation with electrical work.
- C. Prepare a floor plan (no larger than 11" x 17") showing each telecommunication outlet. Install next to termination backboard. Label each outlet as described in section 3.8 of this specification. Submit labeling plan to owner for approval.

3.2 RACEWAY SYSTEM

- A. Provide raceway system per plans and specs.

- B. Install capped bushings on raceways as soon as installed.

3.3 OUTLET

- A. Provide outlet as indicated on the low-voltage systems drawings.
- B. Outlet backboxes shall be minimum 4-square deep backboxes.
- C. Pair untwist at the termination shall not exceed 12 mm (one-half inch).
- D. Bend radius of the horizontal cable shall not be less than 4 times the outside diameter of the cable.
- E. The cable jacket shall be maintained to within 25mm (one inch) of the termination point

3.4 PULLBOXES

- A. Provide pullboxes as required. Provide at a minimum where (3) 90 degree bends are exceeded with a single conduit run.

3.5 HORIZONTAL COPPER DISTRIBUTION

- A. Do not exceed 295 ft. cable length between Main Distribution Facilities (MDF)/Intermediate Distribution Facility (IDF) and terminal or workstation terminal point.
- B. When pulling the cable the cable should move freely at all times and be protected from sharp edges. When pulling around tight corners or multiple corners, two or more people should be used to guide the cable and prevent damage. Cable ties should be lightly tightened to avoid any visible stress which can change the characteristics of the UTP cable.
- C. Terminate workstations and terminals on jacks mounted in multi-port faceplates. When terminating the device end of the cabling, pull 12" of wire out of the outlet box, trim and terminate the cabling. After termination, push the cabling back up the conduit, leaving approximately 7" of wire in the box. Allow the remainder to remain slack as it exits the upper end of the conduit.

3.6 EQUIPMENT RACKS/CABINETS

- A. Securely fasten floor mounted equipment racks to the floor following the manufacturer's recommendations.
- B. Provide grounding per plans.
- C. Securely fasten wall mounted equipment to the wall following the manufacturer's recommendations.
- D. Provide and install cable management hooks at the MDF to neatly route cable.

3.7 LABELING

- A. Label each cable, work area outlet location, cabinet, grounding system, etc. with a computer generated or machine printed label. Each label shall be easily visible and made of durable quality. Machine printed adhesive labels are required.
- B. Equipment Identification:

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1. All telecommunications equipment and parts furnished and installed by the contractor shall be equipped with a permanent numbering identification indicating its individual location within the building. Label numbers shall be comprised of the Telecommunication Closet room-rack-row-port. Equipment to be identified shall include, but not be limited to, faceplates, jacks, patch panel, all wiring, cabinet, racks and 66 blocks.

C. Faceplates:

1. Faceplates shall be labeled with Telecommunication Closet room-rack-row-port specific to drop location.
2. The first labeling will be handwritten using a permanent marker in the recess beneath the clear plastic label cover.
3. The second label will be a machine printed adhesive label placed over the top and corresponding to the hand printed labeling. The clear plastic label cover will then be installed. Hand lettering will not be permitted on the outside of the faceplates except under the machine printed label. Handwritten labels should not "bleed" through the machine printed label.

D. Jacks:

1. All jacks at both the device and patch panel locations shall be identified with a permanent marker, handwritten using Telecommunications Closet room-rack-row-port specific to the drop location on the side of the jack. This labeling shall not be visible from the exterior face of the jack.

E. Patch Panels:

1. All patch panels located in the Telecommunications Closets shall be identified by using rack-row-port specific to the drop location.

F. Wiring:

1. All station wiring will be identified on both ends with a permanent marker, handwritten using Telecommunication Closet room-rack-row-port specific to the drop location on white tape approximately 3 inches below the cut end of the wire.

G. Racks and Cabinets:

1. Label racks and cabinets as shown on the plans.

3.8 TESTING

A. Copper based horizontal systems (data and voice):

1. Test each data basic link (outlet to punchdown block) according to TIA/EIA 568A - Addendum 1, 2 and 5, TSB - 67, TSB - 95 with a level II hand held tester.
2. For each cable, prepare and submit test report to owner.

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B. Coax based horizontal systems (broadband and security):

1. Test each cable for attenuation, impedance, resistance and noise per manufacturer=s recommendations.
2. Prepare and submit test report to Owner.

END OF SECTION 16780

